

Prozeal Green Energy Limited

Strategic assessment of Indian solar power market

Final report

March 2025



DLT



by **S&P Global**

Contents

1	Macroeconomic overview	1
1.1	Economic indicators	1
1.2	GVA performance	2
1.3	Outlook	2
1.3.1	Per capita electricity consumption	2
1.3.2	Urbanization	3
1.4	Aatmanirbhar Bharat Abhiyan	4
1.5	India's RE initiatives to reach climate goals	5
2	Overview of power sector	7
2.1	Global power scenario	7
2.2	Review of Indian power demand-supply scenario	7
2.2.1	Power supply mix	7
2.3	Demand-supply outlook for India	9
2.3.1	Expected capacity installation by Fiscal 2030	9
2.4	Overview of the sector's key challenges and risk factors	10
3	Overview of Solar Energy sector	12
3.1	Global Solar Market	12
3.1.1	Review of Global Solar PV Capacity Additions	12
3.1.2	Global solar outlook (CY2024-2029)	13
3.1.3	Solar energy opportunities in Nepal, Portugal, and SEA countries	13
3.2	Evolution of Solar Power in India	15
3.3	Key drivers for solar energy capacity additions	17
3.4	Review of policies	23
3.4.1	Key incentives for various solar schemes	23
3.4.2	State level key policy provisions	24
3.5	Project Capex, EPC and O&M costs movement	25
3.6	Outlook of overall grid-connected solar energy capacity additions	26
3.7	Outlook on rooftop solar PV capacity additions	28
3.7.1	Grid connected rooftop capacity stood at ~15.7 GW as of December 2024	28
3.8	Outlook on rooftop solar PV capacity additions in India	29
3.9	Outlook on C&I solar capacity addition in India	29
3.10	Policy support in terms of incentives for C&I capacity addition	31
3.11	Broad overview of Green hydrogen demand	32
3.12	Outlook on solar hybrid/RTC capacity additions in India	33
3.13	Key drivers for solar-hybrid hybrid/RTC capacity additions	33
4	Overview on Indian Solar EPC Market	34
4.1	Introduction	34
4.2	EPC project: Turnkey versus balance of plant	35
4.3	Project execution using in-house EPC vs outsourcing to specialized EPC players	35
4.3.1	Pros and cons of different business models	36
4.4	Outlook on solar EPC Market	37
4.5	Business models for Solar O&M	39
4.6	Key drivers, threats, and challenges for Indian Solar O&M Market	40
4.6.1	Key Drivers which affect the Indian Solar O&M market:	40
4.6.2	Threats and challenges which affect the O&M market:	40
4.7	Assessment of Solar O&M Market	41

4.8	Key threats and challenges for EPC of solar pumps	41
5	Assessment of EV Charging infrastructure.....	43
5.1	Existing EV charging infrastructure market	43
5.2	Business models for development of EV charging infrastructure	44
5.2.1	<i>Types of business models.....</i>	<i>44</i>
5.3	Regulatory framework and incentives for setting up charging infrastructure	45
5.4	Growth drivers and challenges for scaling up charging infrastructure	45
6	Heating, Ventilation, and Air Conditioning (HVAC) Market.....	47
6.1	Industrial decarbonisation in heating and cooling	47
6.2	Growth drivers	47
6.3	Overall market size for HVAC	48
7	Overview of key players.....	50
7.1	Competitive mapping of Solar O&M players in India	50
7.2	Competitive landscape of EV charging infrastructure players	51
7.3	Competitive mapping of solar EPC players.....	53
8	Key challenges/threats	58
8.1	Key challenges and threats impacting renewable energy sector.....	58
8.1.1	<i>Threats</i>	<i>58</i>
8.1.2	<i>Challenges</i>	<i>58</i>

DLT



List of tables

Table 1: Real GDP annual growth forecast of major economies (figures in %)	2
Table 2: Sector-wise focus of <i>Aatmanirbhar Bharat</i> Vision	4
Table 3: Safeguard and customs duty trajectory	18
Table 4: State wise solar park approved capacity (GW) as of December 2024.....	21
Table 5: Various open access models	30
Table 6: Comparison of self O&M and Third-party O&M.....	39
Table 7: Key players for Solar O&M	50
Table 8: Competitive assessment of key players in EV charging space	52
Table 9: Key players in HVAC	53
Table 10: Key Operational and Financial parameters of leading project developers	54

List of figures

Figure 1: Comparison of India's economy with other major nations.....	1
Figure 2: GVA at basic prices	2
Figure 3: Per capita electricity consumption (in kWh)	3
Figure 4: Urban population as a % of the total population of India.....	4
Figure 5: Global power mix- installed capacity	7
Figure 6: Details of source wise installed capacity as of December 2024 (GW, % share)	8
Figure 7: Fuel-wise installed capacity in past 10 years (GW)	8
Figure 8: All India installed capacity addition by Fiscal 2030 (in GW)	9
Figure 9: Details of installed capacity	10
Figure 10: Annual solar capacity additions in major economies	12
Figure 11: Global solar PV installed capacity registered about 25% CAGR between 2016 and 2023	13
Figure 12: Projected cumulative solar PV capacity CY24-29	13
Figure 13: Trend in cumulative solar capacity installation in India	15
Figure 14: States that helped drive solar capacity addition in India	16
Figure 15: Growth drivers for solar sector in India.....	17
Figure 16: Module prices declined over 80-85%% from Fiscal 2010 to 2024 (USD/Wp).....	18
Figure 17: Competitively bid solar power tariffs are much lower than coal-based power tariffs	19
Figure 18: Cell efficiency comparison.....	22
Figure 19: EPC cost, Rs million/ MWp.....	25
Figure 20: Declining Module prices leading to lower capital costs	26
Figure 21: Demand, experience and technological improvement leading to lower annual O&M costs	26
Figure 22: Year wise expected solar capacity addition	27
Figure 23: Projected rooftop capacity additions over Fiscals 2025-2030.....	29
Figure 24: Open access utility scale capacity additions (FY25-FY30)	31
Figure 25: Checklist of an EPC model.....	35
Figure 26: Third Party Solar EPC Market India	37
Figure 27: Solar project O&M	38
Figure 28: India third party solar O&M services, Fiscal 2024 to 2029	41
Figure 29: Public charging stations across different states	43
Figure 30: Type of chargers in India	44
Figure 31: Favourable policies and regulations to drive EV charging infrastructure	45
Figure 32: HVAC Market in India (UDS Mn) is expected to grow at CAGR of 18.2% over FY 25 to FY30	49

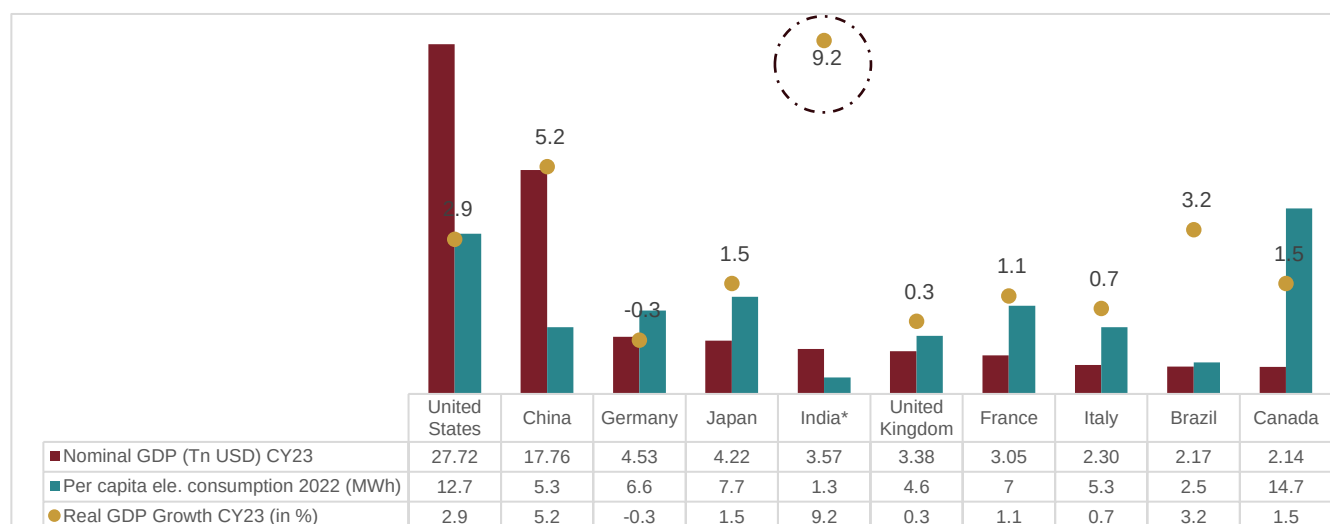
1 Macroeconomic overview

1.1 Economic indicators

India's gross domestic product (GDP) at constant (Fiscal 2012) prices was Rs. 176.5 trillion (first revised estimates) for Fiscal 2024 vis-à-vis the final estimate of Rs.161.6 trillion for Fiscal 2023 as per data released by the National Statistical Office (NSO) in February 2025. This translates into a growth of 9.2% over Fiscal 2023. As per second advanced estimates by NSO, India's real GDP in Fiscal 2025 at Constant Prices is estimated to attain a level of Rs.187.95 trillion in fiscal 2025.

India has become the fifth largest economy in the world in 2023, according to the International Monetary Fund's (IMF) World Economic Outlook (April 2024). As per IMF GDP Forecasts (July 2024), India's GDP growth is estimated at 6.5% in 2025, the highest among the top 10 economies. Additionally, World Bank has forecasted India's GDP to grow at 7% in Fiscal 2025.

Figure 1: Comparison of India's economy with other major nations



*India GDP data as of February 2025 as per NSO for Financial Year 2024,

Source: World Economic Outlook Database (October 2024) by IMF; IEA, CEA, Crisil Intelligence

Indian GDP has been growing consistently. In the last 10 years, except for years affected by the COVID-19 pandemic, India's growth has been highest amongst the top 10 economies. With the receding risk of global recession, India has been identified as an economic growth centre by various International Agencies as well as global rating firms.

GDP grew 6.7% on-year in the first quarter of Fiscal 2025, in line with Crisil forecast of 6.8%. This was a deceleration vs the fourth quarter of Fiscal 2024, which saw the economy expand 7.8%. And in the first quarter of Fiscal 2024, the economy grew 8.2%. On the supply side, GVA growth of 6.8% was slightly higher than 6.7% GDP growth.

From the demand side, the decline in government consumption spending was a drag on GDP growth. And reducing growth in net taxes limited the rise in GDP over gross value added (GVA) growth. That being said, both private consumption and fixed investments picked up in the quarter. On the supply-side, despite healthy growth of 7.0%, manufacturing was slower than in the last quarter Fiscal 2024, while agriculture and services improved. However, the improvement in agriculture was relatively modest, which capped the rise in GDP.

In July 2024, the IMF released World Economic Outlook. As per the IMF, Economic activity was surprisingly resilient through the global disinflation of 2022–23. The IMF estimated global growth at 3.3% in 2023 and projected it to continue at the same pace in 2024 and 2025. Growth in India is projected to remain strong at 7.0% in 2024 and 6.5% in 2025, with the robustness reflecting continuing strength in domestic demand and a rising working-age population.

Table 1: Real GDP annual growth forecast of major economies (figures in %)

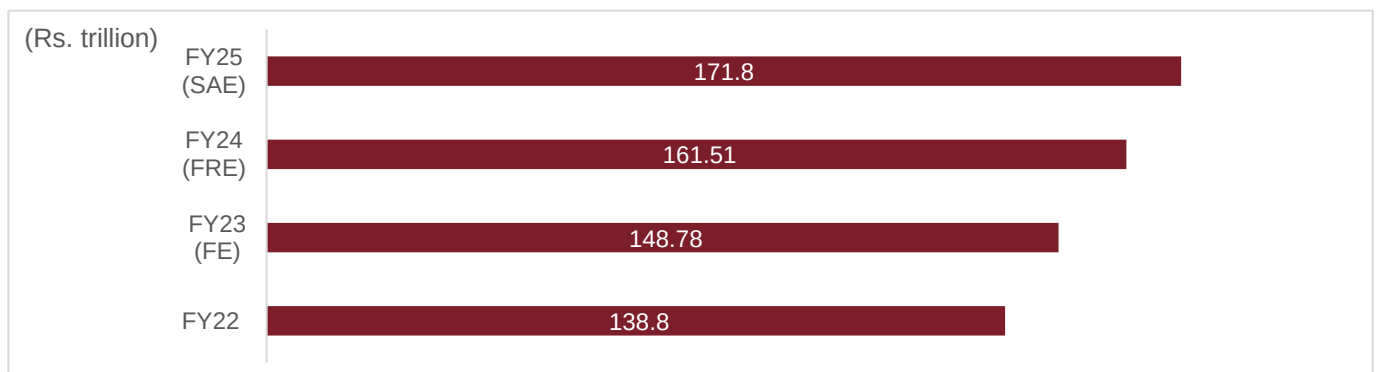
Country	CY24	CY25	CY26	CY27	CY28	CY29
Brazil	2.1	2.4	2.1	2.0	2.0	2.0
Canada	1.3	2.4	1.9	1.7	1.7	1.7
China	5.0	4.5	3.8	3.6	3.4	3.3
France	0.9	1.3	1.6	1.5	1.4	1.3
Germany	0.2	1.3	1.5	1.1	0.8	0.7
India*	7.0	6.5	6.5	6.5	6.5	6.5
Italy	0.7	0.9	0.2	0.3	0.8	0.8
Japan	0.7	1.0	0.8	0.6	0.6	0.4
United Kingdom	0.7	1.5	1.7	1.7	1.6	1.4
United States	2.6	1.9	2.0	2.1	2.1	2.1

*For India financial Year

Source: IMF, Crisil Intelligence

1.2 GVA performance

The real GVA has grown by 8.6% in Fiscal 2024 from 7.2% in Fiscal 2023. This GVA growth has been mainly due to a significant growth of 9.9% in Manufacturing sector in Fiscal 2024, compared to -2.2% in Fiscal 2023 and growth of 7.1% in Fiscal 2024 compared to 1.9% in Fiscal 2023 for Mining & Quarrying sector. As per the second advanced estimates by NSO, the real GVA is expected to grow by 6.4% in Fiscal 2025 over Fiscal 2024.

Figure 2: GVA at basic prices


FRE: first revised estimates; FE: final estimates; SAE: Second advanced estimates

Source: Ministry of Statistics and Programme Implementation, Crisil Intelligence

1.3 Outlook

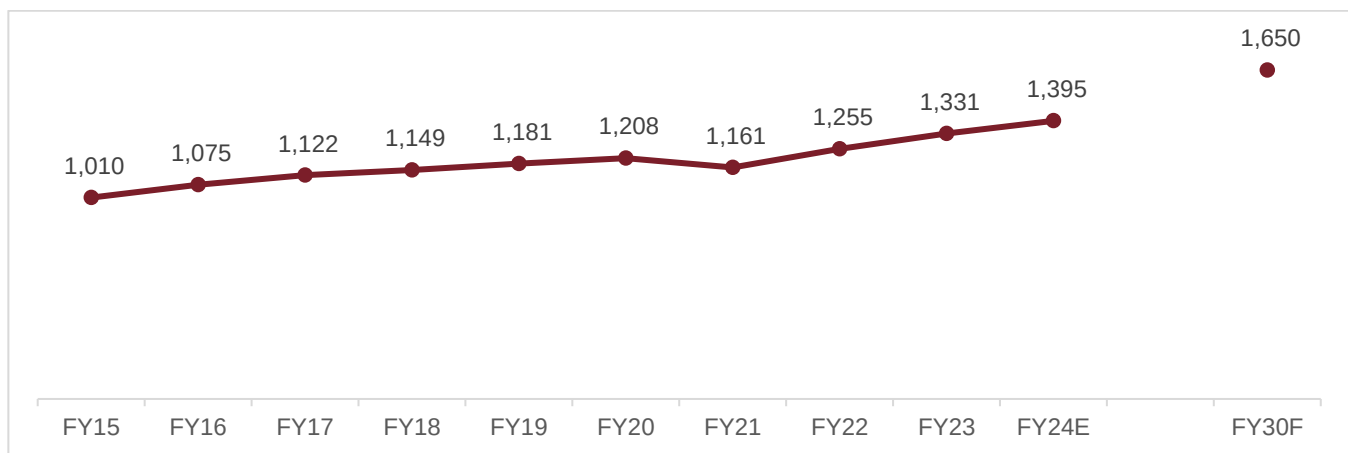
1.3.1 Per capita electricity consumption

As per the Central Electricity Authority (CEA), the electricity consumption per person rose to 1,395 kWh in Fiscal 2024 (provisional data), from 1,010 kWh in Fiscal 2015 at a CAGR of 3.7%, primarily led by increasing economic activities, rising domestic consumption, rural and household electrification. Post successive on-year growth in consumption, demand declined in Fiscal 2021, particularly from high-consuming industrial and commercial categories on account of weak economic activity following the outbreak of the COVID-19 pandemic. In Fiscal 2022, though, per capita consumption rebounded to 1,255 kWh on the back of a recovery in demand, with a similar trend estimated in Fiscal 2023. Similarly, the energy requirement grew at 4.7% CAGR from Fiscals 2015 to 2023 i.e., from 1,069 BUS to 1,622 BUS.

As seen in **Figure 1**, despite this healthy increase, the per-capita electricity consumption remains significantly lower than in other major economies. Developing countries, such as Brazil and China, have significantly higher per-capita electricity consumption than India.

Between Fiscals 2024 and 2030, India's per capita electricity consumption is expected to grow at ~5-7% CAGR. Per capita consumption is expected to gradually improve in the long term as well, as power demand picks up on the back of improvements in access to electricity, in terms of quality and reliability, rising per capita income, increasing EV penetration, railway electrification, intensive rural electrification, resulting in the realisation of latent demand from the residential segment, increased penetration of consumer durables. However, there are a few factors which could restrict the growth, such as improved energy efficiency, focus on T&D loss reduction, sustainability targets, and increasing share of services in GDP. Consequently, Crisil Intelligence expects per capita electricity consumption to reach 1,600-1,650 kWh by Fiscal 2030.

Figure 3: Per capita electricity consumption (in kWh)



E: Estimated; F: Forecast

Source: Central Electricity Authority of India (CEA), Crisil Intelligence

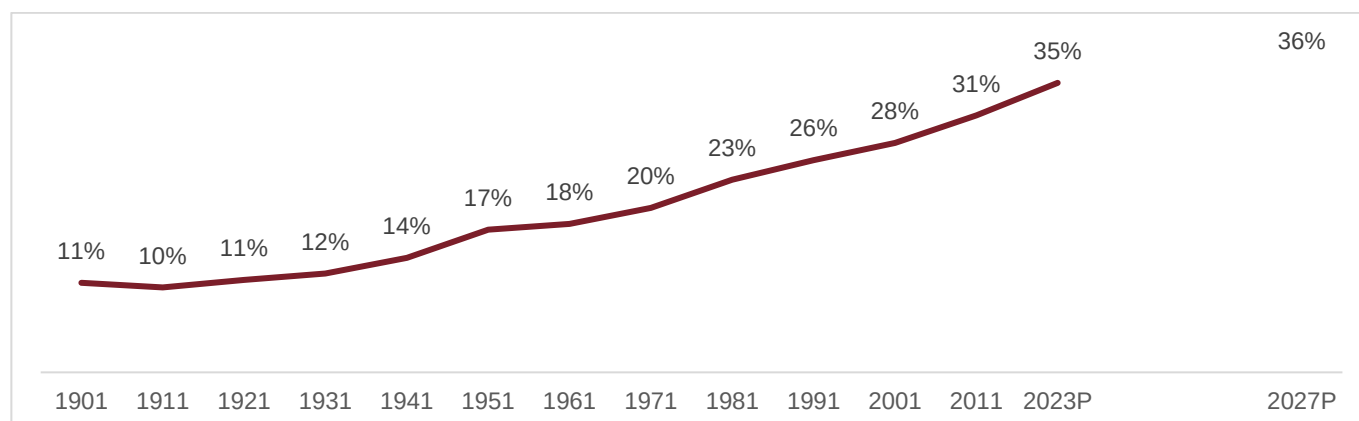
India's power consumption is expected to increase sharply to approximately 3,776 TWh by 2041-42 as per CEA, primarily due to rapid economic and industrial growth. However, meeting this demand poses challenges due to an unstable power supply, driven by variable output from domestic fuel sources and the renewable energy generation, particularly from solar and wind. This volatility leads to unpredictable prices for imports. In light of the same, there is a growing recognition of the role renewable energy sources can play in meeting this demand. Further, the Indian government has taken various initiatives to encourage the usage of renewable energy. Notably, in the Union Budget for Fiscal 2023, an allocation of approximately US\$ 1.2 billion was earmarked for the Ministry of New and Renewable Energy, Union of India, signaling a significant commitment towards advancing renewable energy infrastructure. Further, the Union Government has waived the Inter-State Transmission System (ISTS) charges for projects getting operational before June 30, 2025, for a duration of 25 years. Additionally, state electricity commissions are mandated to procure a fixed percentage of power from renewable sources, ensuring a steady demand and market for renewable energy. These initiatives have led commercial and industrial players to shift their focus towards leveraging local renewable sources.

1.3.2 Urbanization

Urbanization is one of the big growth drivers, as it leads to rapid infrastructure development, job creation, development of modern consumer services, and mobilisation of savings.

The percentage of the urban population in India's overall population, which stood at ~31% in 2011, has been consistently rising over the years, and is expected to reach 36% by 2027, spurring increasing consumer demand.

Indeed, urban consumption in India has shown signs of improvement and given India's favourable demographics, along with rising disposable income, the trend is likely to continue and drive the country's economic growth.

Figure 4: Urban population as a % of the total population of India


P: Projected

Source: Census 2011, Report of The Technical Group on Population Projections by Ministry of Health & Family Welfare (July 2020), Crisil Intelligence

1.4 Aatmanirbhar Bharat Abhiyan

Production Linked Incentives (PLIs) in the 14 sectors for the *Aatmanirbhar Bharat* vision received an outstanding response, with the potential to create 6 million new jobs (as per government estimates).

The five focus points of the *Aatmanirbhar Bharat Abhiyan* are economy, infrastructure, system, vibrant demography, and demand. Its five phases are:

- Phase I: Businesses including MSMEs
- Phase II: Poor, including migrants and farmers.
- Phase III: Agriculture
- Phase IV: New horizons of growth
- Phase V: Government reforms and enablers

Table 2: Sector-wise focus of Aatmanirbhar Bharat Vision

Sector	Government spends	Key schemes
Renewable energy	~Rs. 1,300 billion	- Rs 45 billion Production Linked Incentive Scheme 'National Programme on High Efficiency Solar PV Modules'. This was further increased by Rs 195 billion in the budget for Fiscal 2023, taking it to Rs 240 billion; in Tranche I 8.7 GW and in Tranche II 39.6 GW capacity were allocated for domestic solar module manufacturing capacity under PLI. - PM Surya Ghar Muft Bijli Yojna: This scheme has a proposed outlay of Rs. 750 billion and aims to light up 10 million households (rooftop solar) by providing up to 300 units of free electricity every month. - Public procurement (Preference for 'Make in India') to provide for purchase preference (linked with local content) in respect of renewable energy (RE) sector - Implementation of Pradhan Mantri Kisan Urja Suraksha Utthan Mahabhiyan (PM KUSUM) scheme; MNRE, in November 2020, scaled up and expanded the PM KUSUM scheme to add 30.8 GW by 2022 with

Sector	Government spends	Key schemes
		central financial support of Rs 344 billion. The scheme has been extended till March 31, 2026 - Approved Models & Manufacturers of Solar Photovoltaic Modules (Requirement for Compulsory Registration) Order, 2019 - List of manufacturers and models of solar PV modules recommended under ALMM Order - Scheme of grid connected wind-solar hybrid power projects - Basic customs duty (BCD) of 25% on solar cells and 40% on modules, respectively, effective April 1, 2022
Power distribution companies (discoms)	~Rs.970 billion	- Rs 1.35 trillion liquidity infusion for discoms via Power Finance Corporation/ Rural Electrification Corporation (PFC/ REC) against receivables - Rebate for payment to be received by generation companies (gencos) to be passed on to industrial customers - Revamped distribution sector scheme (RDSS) to help discoms improve their operational efficiencies and financial sustainability by providing result-linked financial assistance; outlay of Rs 3,037.58 billion over 5 years i.e., Fiscals 2022 to 2026. The outlay includes an estimated Government Budgetary Support (GBS) of Rs 976.31 billion.
Mining	Nil	- Expected to offer 500 mineral blocks, including 50 coal - Promoting commercial coal mining (ordinance to remove captive end-use restriction passed in January 2020); government to expedite policy formulation and auction process - Government to allow composite exploration/auction of coal bed methane reserves for extraction - Rebate offered on revenue sharing quantum to incentivise early operationalisation/ higher produce - Provision of Rs 500 billion for evacuation infrastructure
New Energy	Rs. ~388 billion	- Rs 181 billion under PLI scheme for Advanced Chemistry Cell (ACC) Battery Storage in India launched in October to achieve 50 GWh manufacturing capacity - Green Hydrogen Policy launched in February 2022 to facilitate production of green hydrogen/green ammonia - PLI scheme on green hydrogen manufacturing with an initial outlay of Rs 197.44 billion with an aim to boost domestic production of green hydrogen

Source: Official portal of the Government of India; various ministries, PIB press releases, Crisil Intelligence

1.5 India's RE initiatives to reach climate goals

Efforts have been made by the Government to increase awareness about the use of renewable energy through the introduction of various schemes. The list of some of the key schemes introduced is given below.

- Permitting Foreign Direct Investment (FDI) up to 100 percent under the automatic route for renewable energy projects
- Scheme for the Development of Solar Parks and Ultra-mega Solar Power Projects with a target of setting up 40,000 MW capacity. Under the scheme, infrastructures such as land, roads, power evacuation systems and

water facilities are developed with all statutory clearances/approvals. Thus, the scheme helps expeditious development of utility-scale solar projects in the country.

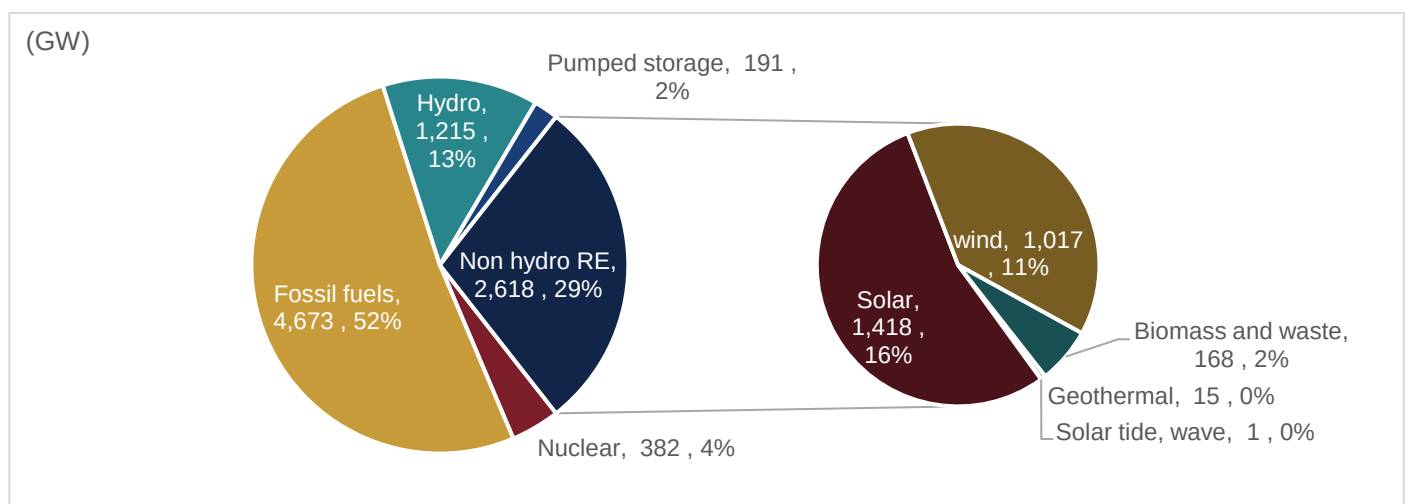
- Central Public Sector Undertaking (CPSU) Scheme Phase-II (Government Producer Scheme) for setting up grid-connected Solar Photovoltaic (PV) Power Projects by Government Producers, using domestically manufactured solar PV cells and modules, with the support of the Viability Gap Funding (VGF), for self-use or use by Government/ Government entities, either directly or through Distribution Companies (DISCOMS).
- Production Linked Incentive scheme 'National Programme on High Efficiency Solar PV Modules' for achieving manufacturing capacity of Giga Watt (GW) scale in High Efficiency Solar PV modules (Tranche- I & II).
- PM-KUSUM Scheme to promote small Grid Connected Solar Energy Power Plants, stand-alone solar powered agricultural pumps and solarisation of existing grid connected agricultural pumps. The scheme is not only beneficial to the farmers but also to the States and DISCOMs. States will save on subsidies being provided for electricity to agriculture consumers and DISCOMs get cheaper solar power at the tail end, saving transmission and distribution losses.
- Rooftop Solar Programme Phase II for grid-connected solar rooftop power plants. Under this Programme, subsidies are provided for the residential sector and performance-linked incentives to DISCOMs for achieving capacity addition in rooftop solar above baseline.
- Green Energy Corridors (GEC): to create an intra-state transmission system for renewable energy projects. Central Financial Assistance (CFA) is provided to set up transmission infrastructure for evacuating power from Renewable Energy projects in a total of ten states (considering both the phases of GEC).
- Investment of Rs. 207 billion, including central support of Rs. 83 billion, for strengthening of interstate transmission system for evacuation and Grid Integration of 13 GW renewable energy from Ladakh.
- National Green Hydrogen Mission launched with an outlay of Rs. 197.44 billion with the aim to make India a Global Hub for the production, utilization, and export of Green Hydrogen and its derivatives.
- Viability gap funding for 4,000 MWh battery energy storage systems and formulation of a detailed framework for pump storage projects.
- Waiver of Inter State Transmission System (ISTS) charges for inter-state sale of solar and wind power for projects to be commissioned by 30th June 2025
- Declaration of trajectory for Renewable Purchase Obligation (RPO) up to the year 2030
- The government has issued orders that power should be dispatched against a Letter of Credit (LC) or advance payment to ensure timely payment by distribution licensees to RE generators.
- Notification of Promoting Renewable Energy through Green Energy Open Access Rules 2022.
- Notification of "The electricity (Late Payment Surcharge and related matters) Rules 2022 (LPS rules).
- Launch of Green Term Ahead Market to facilitate the sale of renewable energy power through exchanges.

2 Overview of power sector

2.1 Global power scenario

As per the US Energy Information Administration (EIA), global installed capacity stood at 9,080 GW as of 2023. Fossil fuels lead the installed base with a 52% share, whereas carbon-free generation sources (nuclear, hydropower, and combined renewables) contribute ~47% and 2% from biomass and waste. Non-hydro renewables lead to carbon-free generation with 29%, followed by hydro at 15% and nuclear with 4%. Within the non-hydro renewables, solar and wind leads with 54% and 39% share, respectively. India stands 4th globally in Renewable Energy Installed Capacity (including Large Hydro), 4th in Wind Power capacity, and 4th in Solar Power capacity.

Figure 5: Global power mix- installed capacity



Note: EIA provided the latest data for 2023 only.

Source: US EIA, Crisil Intelligence

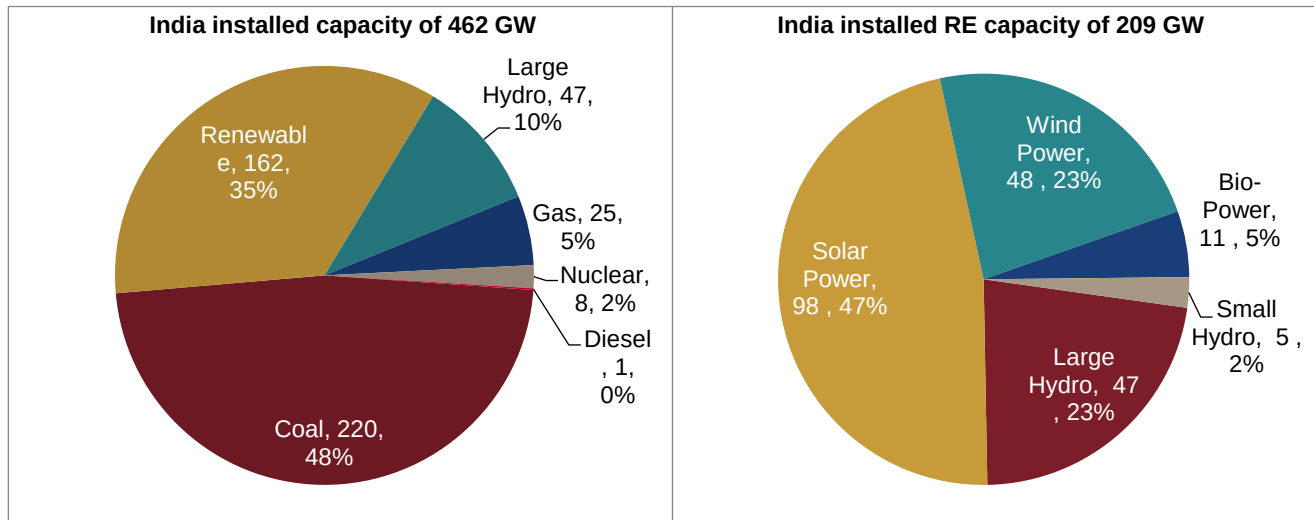
In 2023, the world saw a remarkable surge in renewable energy capacity, with a nearly 50% increase to approximately 510 GW - the highest growth rate in the past 20 years. As the growth in renewable energy sources in Europe, the United States, and Brazil reached record levels, China's progress was remarkable. In an astonishing surge, China's solar PV installations in 2023 alone surpassed the global total in 2022. Furthermore, the country's wind power capacity additions experienced a significant 66% increase compared to the previous year. Approximately 75% of the new renewable energy capacity worldwide came from solar PV installations alone.

2.2 Review of Indian power demand-supply scenario

2.2.1 Power supply mix

The total installed generation capacity as of December 2024 was 462 GW, of which ~119 GW of capacity was added over Fiscal 2018-25. The overall installed generation capacity has grown at a CAGR of 6.0% over Fiscals 2014– 24. Coal and Lignite-based installed power generation capacity has maintained its dominant position over the years and accounts for ~47% as of December 2024. However, RE installations (including large hydroelectric projects) have reached ~209 GW capacity as of December 2024, compared with 63 GW as of March 2012, constituting ~53% of total installed generation capacity as of date. This growth has been led by solar power, which rapidly rose to ~98 GW from 0.9 GW over the same period.

Figure 6: Details of source wise installed capacity as of December 2024 (GW, % share)

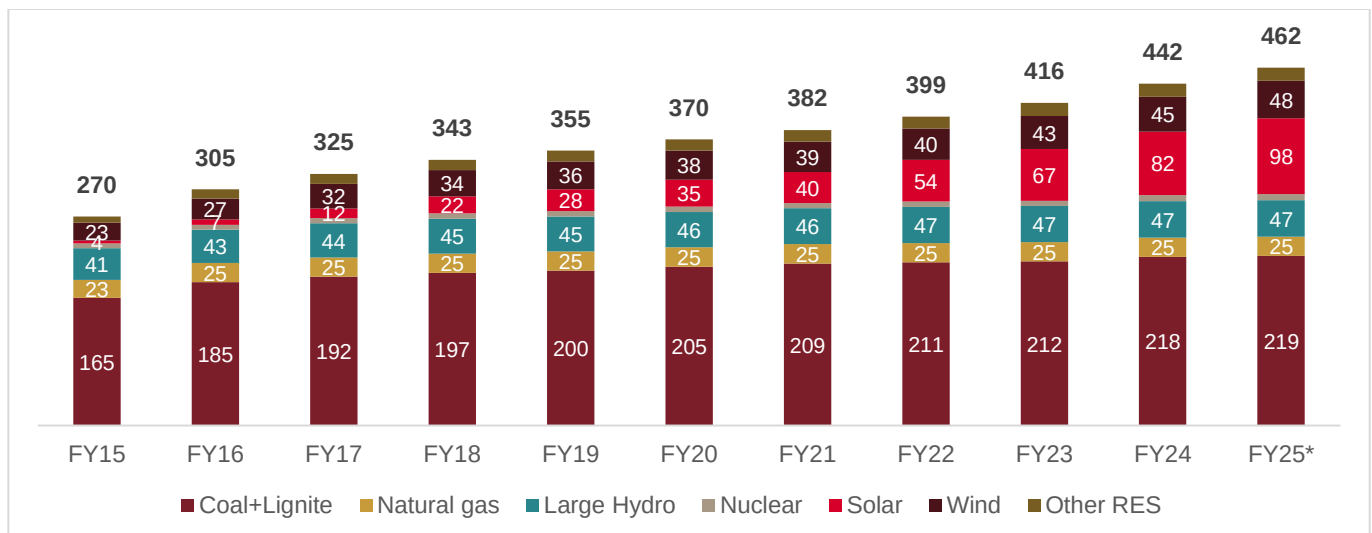


Source: CEA, Crisil Intelligence

The Electricity Act, 2003 and competitive bidding for power procurement, implemented in 2006, encouraged the participation of private market participants who have announced large capacity additions. As a result of competitive bidding, capacities of ~22 GW (Fiscals 2014-23) were added by the private sector, which accounted for 73.0% of the total additions. Moreover, a strong government thrust on RE and decreasing tariffs (with falling capital costs and improving efficiency) also supported RE capacity additions. Investments from foreign funds participating in fundraising activities for the sector have also enabled growth.

The share of renewable energy (including large hydro) in the total supply mix was ~5% in Fiscal 2015, which has now increased to 23% in Fiscal 2025 (as of December 2024). The RE generation has increased at a CAGR of ~17% in the last 10 years. The share of solar and wind energy was ~12.5% of the total energy supplied as of December 2024 during Fiscal 2025. The share of large hydro was ~9.5% and the remaining 1% is from other RE sources.

Figure 7: Fuel-wise installed capacity in past 10 years (GW)



* FY25 as of December 2024; Other RE sources: Incl. small hydro, biomass/bagasse and waste to energy

Source: CEA, Crisil Intelligence

2.3 Demand-supply outlook for India

2.3.1 Expected capacity installation by Fiscal 2030

India's installed generation capacity, which stood at 356 GW at the end of Fiscal 2019 has reached ~442 GW in Fiscal 2024 (as of March 2024) on the back of healthy renewable capacity additions (including solar, wind, hybrid, and other renewable sources) even as additions in coal and other fuels have declined. In Fiscal 2024, renewables (excl. large hydro) accounted for ~33% of the installed capacity, up from ~22% in Fiscal 2019, whereas coal-based capacity tapered to ~49% over the same period.

Capacity additions in the conventional power generation segment are projected to be around 30-35 GW from Fiscals 2025 to 2030, driven by higher than decadal average power demand. Fresh project announcements are limited as players are opting for the inorganic route for expansion given the availability of assets at reasonable valuations. In fact, 4.8 GW of stressed power assets are awaiting debt resolution. However, the need for generation capacity equipped for flexible operations to ramp up or down quickly is critical to meet peak demand as generation from renewable capacities is intermittent in nature. Crisil Intelligence expects 25-27 GW of coal-based power to be commissioned over Fiscals 2025-30. Coal capacity additions are expected to be driven entirely by the central and state sectors, as major private gencos continue to focus on expanding RE capacity.

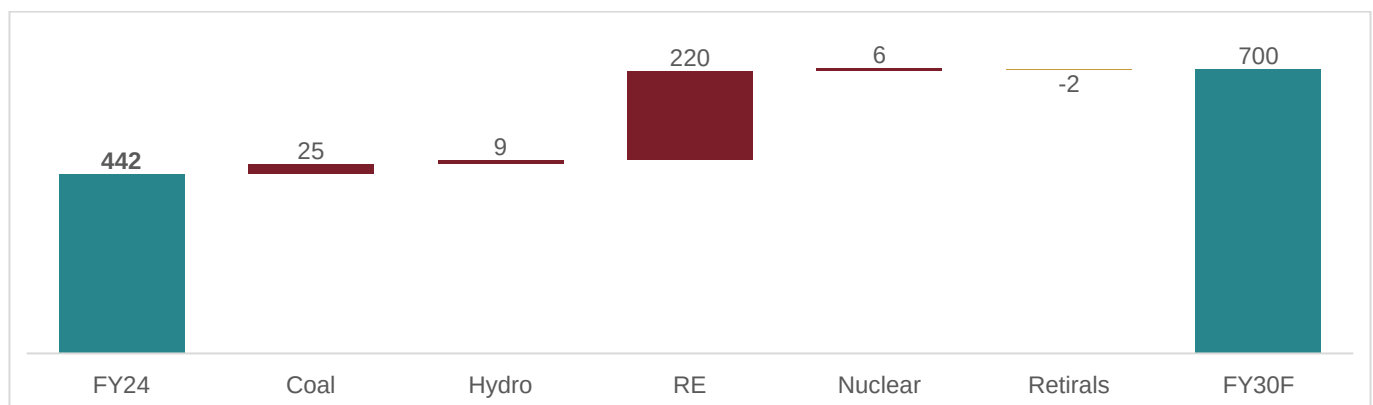
Nuclear power capacity additions of 6-7 GW are expected during the period as ongoing projects at Kakrapar, Kalpakkam, and Rajasthan are nearing completion. Nine reactors with a total capacity of 7.3 GW are under construction which are expected to be commissioned by 2030.

Crisil Intelligence expects 8-9 GW of hydro power installations and 32-35 GW of energy storage solutions including 8.5-9.5 GW pumped hydro storage projects (PSP) capacity additions, and 23-24 GW of Battery Energy storage system (BESS) over Fiscals 2025-2030.

Old and inefficient coal plants, to the tune of 14-15 GW (mainly state-owned) were to be retired. However, as per a CEA notification issued on January 20, 2023, power utilities have been advised against retiring any thermal units until 2030. Instead, they are encouraged to carry out renovation and maintenance (R&M) for life extension and to improve the flexibility and reliability of thermal units.

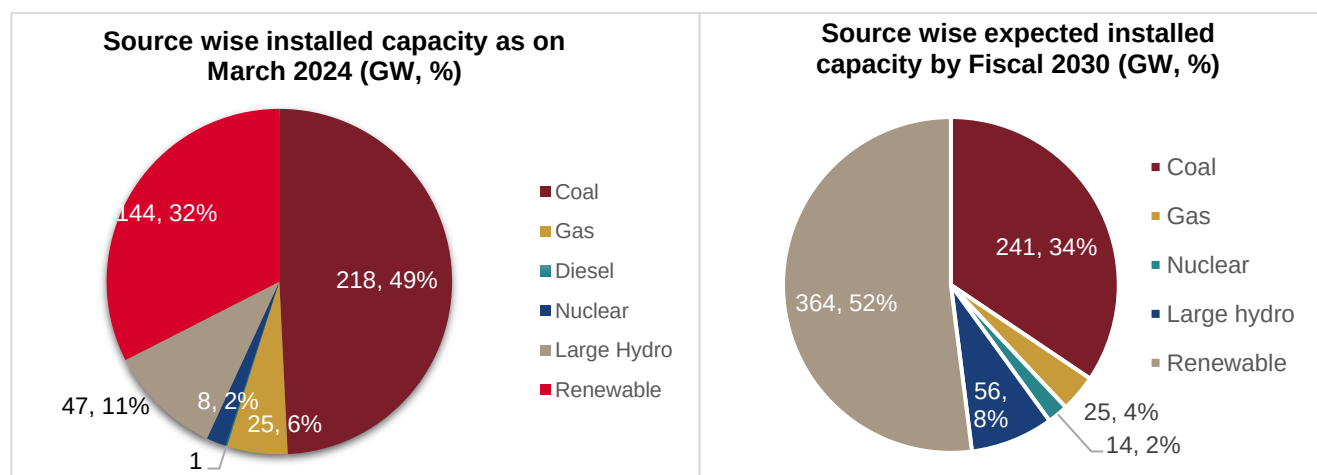
By Fiscal 2030, RE capacity (excl. large hydro) of over 220 GW is expected to be driven by various government initiatives, favourable policies, competitive tariffs, innovative tenders, development of solar parks, green energy corridors, etc. RE capacity is estimated to account for about 50% of the installed capacity of 700-710 GW by Fiscal 2030.

Figure 8: All India installed capacity addition by Fiscal 2030 (in GW)



Source: CEA, Crisil Intelligence

The share of renewable energy, including large hydro, is expected to reach above 50%. However, the share of RE in terms of energy supply is expected to be about 35-40% by Fiscal 2030.

Figure 9: Details of installed capacity


Source: CEA, Crisil Intelligence

2.4 Overview of the sector's key challenges and risk factors

Low power offtake by discoms and credit risk

Despite significant availability of power, offtake by discoms in various Indian states is low on account of their weak financial position. In fact, some discoms opt for load shedding instead of buying power as they face revenue under-recovery (a gap between ACS and ARR). The national average of under-recovery was Rs 0.48 per kWh in March 2023 (as per UDAY portal). Also, counterparty credit risk arising from the weak financials of discoms is an underlying risk as reflected in high receivables of gencos.

Financial health of generators

Private sector coal-based power plants without long-term power purchase agreements (PPAs) are struggling due to underutilization, with an average PLF of ~57% over the past five years. Although the PLF has improved to 68.5% since Fiscal 2024, driven by increased energy demand, the financial performance of these plants has deteriorated, characterized by declining sales, shrinking net margins, and rising debt levels. The financial health of discoms remains fragile, despite the implementation of the UDAY and other bailout schemes, and they are unlikely to enter into new long-term PPAs in the near future due to existing contractual obligations. As a result, private power producers are expected to face challenges in servicing their debt, which will have a negative impact on operational projects and therefore there is a limited participation from private players to invest in additional thermal projects.

Fuel availability

For thermal plants, which form 80% of the installed capacity of conventional energy, fuel accounts for a large proportion of operating costs at 75-80%. Over Fiscals 2011-14, domestic coal availability was a major issue as total non-coking coal production grew a mere 1.7%, owing to stringent environmental regulations. This partly contributed to a decline in PLFs from ~75% in Fiscal 2011 to ~69% in Fiscal 2025 (till December 2024). Also, players were compelled to rely more on expensive imported coal which adversely impacted the returns of players. Despite increasing coal production, insufficient rake availability led to inadequate coal dispatches to plants, which were reeling under increased power demand. However, going forward, coal-based plants will be increasingly utilised for flexible operations to service rising peak demand, particularly those plants commissioned over the past decade and those in the commissioning pipeline.

There are challenges on the gas front too. Availability of domestic gas reduced sharply after production from Reliance Industries' KG-D6 field plummeted. Over the years, government support for gas-based generation in terms of gas supply assurance has dwindled, thereby leaving gas-based plants, which typically operate on domestic gas, short on fuel supply. The same is reflected in PLFs of gas-based plants which remained stagnant at 15-18% over the last five years.

Timely execution of projects

Power projects are highly capital intensive and have a long gestation period. Therefore, completion of projects in a time bound manner is very critical for developers to avoid huge time and cost overruns. In the past, thermal power projects witnessed significant cost overruns on account of delays in getting clearances, land acquisition and achieving financial closure. In fact, certain projects saw cost overruns as high as ~70%, resulting in total project expenditure escalating to Rs 75 million per MW from an initial estimate of Rs 45 million per MW.

Hydro power projects have also been crippled due to execution challenges. Securing necessary approvals (environmental and forest clearances), land acquisition; relocation of project-affected people, inadequate infrastructure for power evacuation, and other logistical issues have constantly hampered the pace of project execution in the sector. Moreover, any delays in the commissioning of projects further raises the cost of the project. This, in turn, escalates the power tariff, thereby increasing the power purchase cost of discoms, making them reluctant to buy electricity from such projects.

Changes in emission norms

Coal-based plants need to adhere to emission norms prescribed by the Ministry of Environment, Forest & Climate Change (MOEF&CC). There is additional capital expenditure associated with the equipment to be installed for keeping emissions below prescribed levels. Thus, any revision in such norms has an impact on the cost of generators.

In December 2015, the government notified the revised standards for coal-based thermal power plants in the country, aimed at minimising pollution and limiting water usage. For example, the upgrade of electrostatic precipitators (ESP), installation of FGD plants and modification of combustion systems, and upgrade of cooling towers to reduce specific water consumption would escalate the capital cost of coal-based plants by Rs 1.5-2.0 million per MW, if adequate land is available for expansion. If land is not available, the cost could rise further. Although capital expenditure incurred towards these modifications can be passed on to discoms, it requires approval from the respective regulatory commission and the PPA clause should also allow it.

Regulatory and policy issues

After the cancellation of coal block allocation in September 2014, a number of plants were stalled due to a lack of fuel. Although the latest coal linkage policy notified in May 2017, SHAKTI, aims to resolve this bottleneck, it has added a clause for providing discounts on existing PPA tariffs which would hurt project returns. Also, the denial of compensatory tariffs on account of international price changes, cancellation of PPA bids by Uttar Pradesh, backing down of wind and solar generation despite their 'must-run' status, and re-negotiation of PPAs are some of the key risks affecting the generation sector.

3 Overview of Solar Energy sector

3.1 Global Solar Market

3.1.1 Review of Global Solar PV Capacity Additions

The strong global thrust on clean energy is driving renewable installations worldwide led by reducing RE generation costs, favourable policies, improved emphasis on energy security and access, and socio-economic benefits. The last decade saw a remarkable evolution in the solar PV segment marked by large scale installations, signification reduction in tariffs and technological advancements.

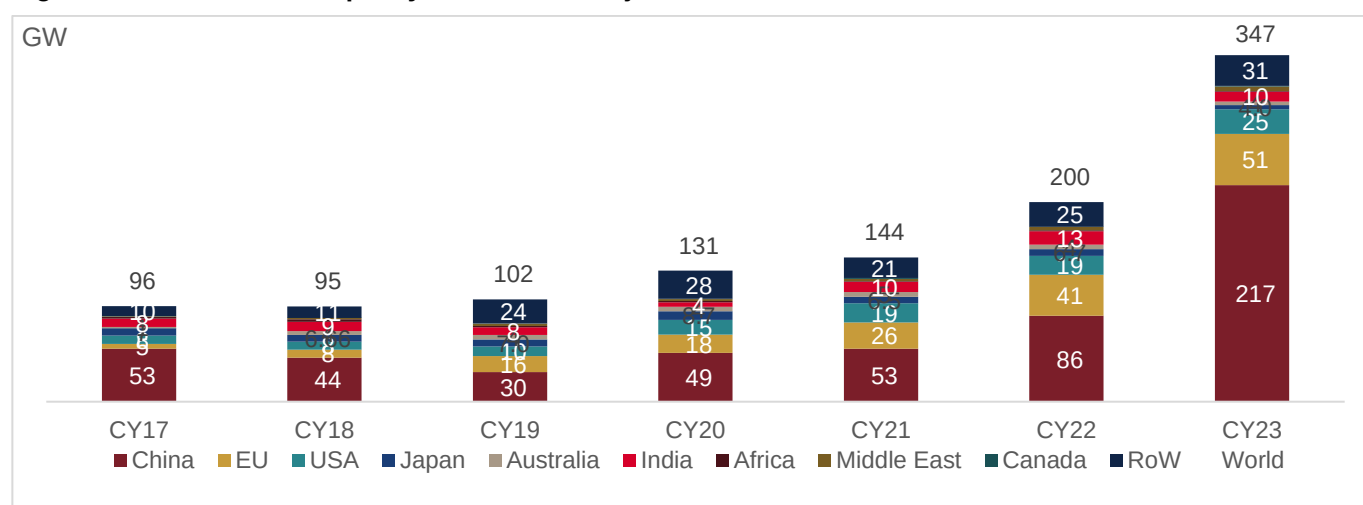
Concerns over climate change are at the heart of the energy shift towards RE and its increasing utilisation will be the key to decarbonisation. Various initiatives, such as Kyoto Protocol, Paris Agreement, Conference of Paris (COP), RE 100, ISA, and subsequent favourable policy interventions, have helped strengthen the RE segment. The transition towards RE is critical to limit the rise in global average temperatures to well below 2 degrees Celsius and ideally below 1.5 degrees Celsius above pre-industrial levels.

Countries that are part of the Paris Agreement are required to submit their plans for climate action, known as the Nationally Determined Contributions (NDCs). These NDCs represent the efforts these countries need to take to reduce national emissions. Various countries have provided policy impetus to the solar PV industry through various mechanisms, such as FiT, 'must run' status, renewable purchase obligations, tax incentives, AD, favourable regulatory frameworks, subsidies, and PLIs. This has accelerated global growth in solar PVs.

Investments in solar PV are expected to increase further as it is rapidly becoming the preferred and lowest-cost option for electricity generation globally. As per IEA, average annual solar generation should grow by an average of 25% between 2022 and 2030 to meet the Net Zero Emissions Scenario by 2050. This translates to an over threefold increase in annual capacity deployment until 2030.

As per IRENA, globally, ~347 GW of solar PV capacity was added in 2023, taking the installed capacity to 1,411 GW, which is a ~32% increase over the previous year. China continued to lead the market with a total cumulative capacity of ~609 GW, whereas the US came in second with ~138 GW, followed by Japan at ~89 GW.

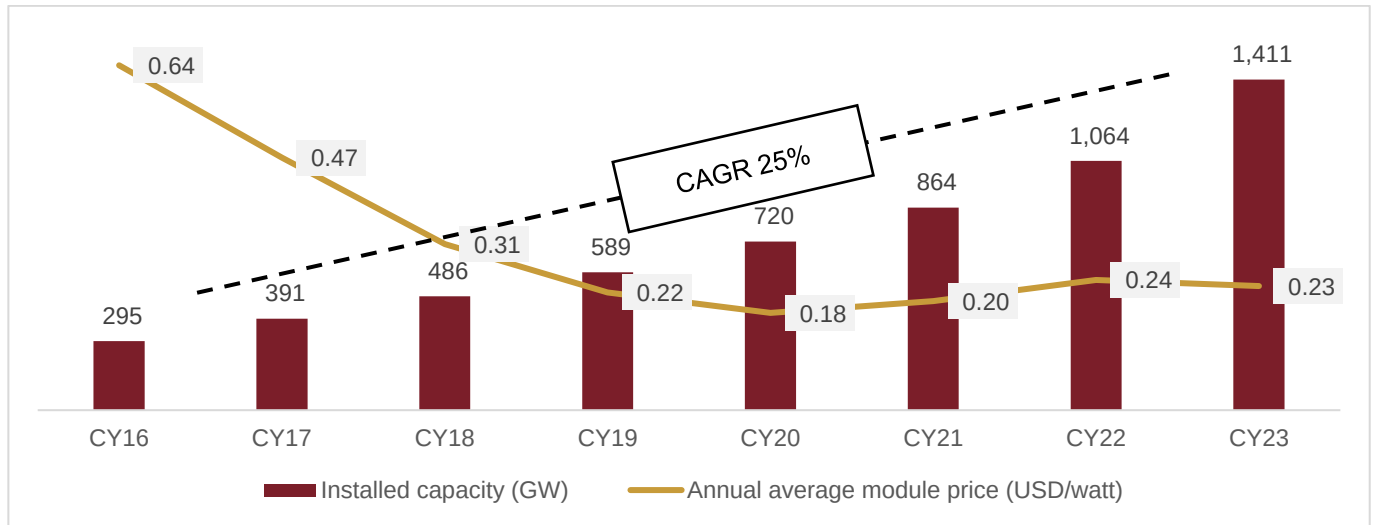
Figure 10: Annual solar capacity additions in major economies



Note: The annual capacity addition numbers pertain to calendar year (January-December)

Source: IRENA Renewable Capacity Statistics 2024; Crisil Intelligence

Figure 11: Global solar PV installed capacity registered about 25% CAGR between 2016 and 2023

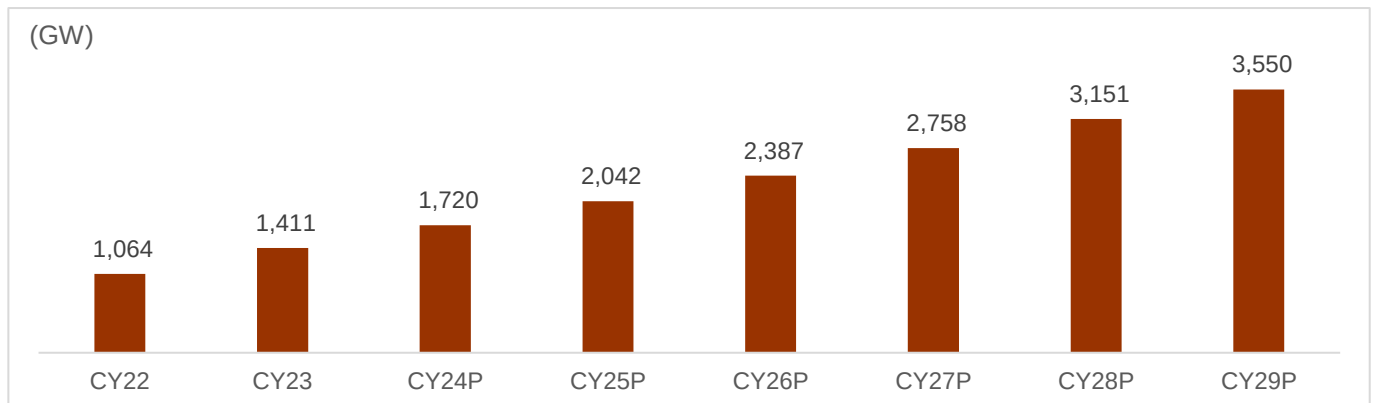


Source: IRENA Renewable Capacity Statistics 2024, Crisil Intelligence

3.1.2 Global solar outlook (CY2024-2029)

IEA has estimated a Solar PV capacity (utility scale) addition of ~2,100 GW over a period of CY2024-29. As per IEA, global renewable capacity additions will continue to increase every year, reaching almost 940 GW annually by 2030 – 70% more than the record level achieved last year. Solar PV and wind together account for 95% of all renewable capacity growth through the end of this decade due to their growing economic attractiveness in almost all countries.

Figure 12: Projected cumulative solar PV capacity CY24-29



(P): Projected

Source: IEA Renewables 2024, IEA, Crisil Intelligence.

3.1.3 Solar energy opportunities in Nepal, Portugal, and SEA countries

- Nepal:** Currently, Nepal gets most of its electricity from hydropower sources. The NEA (Nepal Electricity Authority) is responsible for operating and distributing electricity in Nepal. The total installed capacity of Nepal is around 3.14 GW out of which 1.9 GW is from private sector, 0.58 GW from NEA, 0.49 GW from NEA Subsidiaries, 116 MW from Solar, 53 MW from NEA thermal plant, and 6 MW from biogas. During Fiscal 2023, the annual national peak demand for electricity reached 1986 MW. Nepal has also exported around 430 MW during the same period. Due to its high-altitude topography and beneficial location (slopes facing south), Nepal gets abundant solar radiation, which can be exploited for the development of solar energy. The average global solar radiation in Nepal varies from 3.6 to 6.2 kWh/m²/day, with around 300 sunny days in a year. These favourable conditions make Nepal ideal location for developing solar energy and providing promising opportunities for development of energy in large parts of the Country. As per the Solar & Wind Energy Resource

Assessment in Nepal (SWERA) report published by AEPC in 2008, Nepal has a potential of 2.1 GW for grid connected solar energy. Considering the unique weather as well as geography, various technologies such as solar PV plants, water heaters, lanterns and solar home systems can be effectively deployed in Nepal.

On December 8, 2020, Nepal submitted its second NDC to the UNFCCC. Nepal has set a target of expanding clean energy generation from approximately 1,400 MW to 15,000 MW by 2030. Of this, 5,000 MW will be built using national resources. It is also committed to ensuring that 15% of the total energy demand is supplied from clean energy sources by 2030.

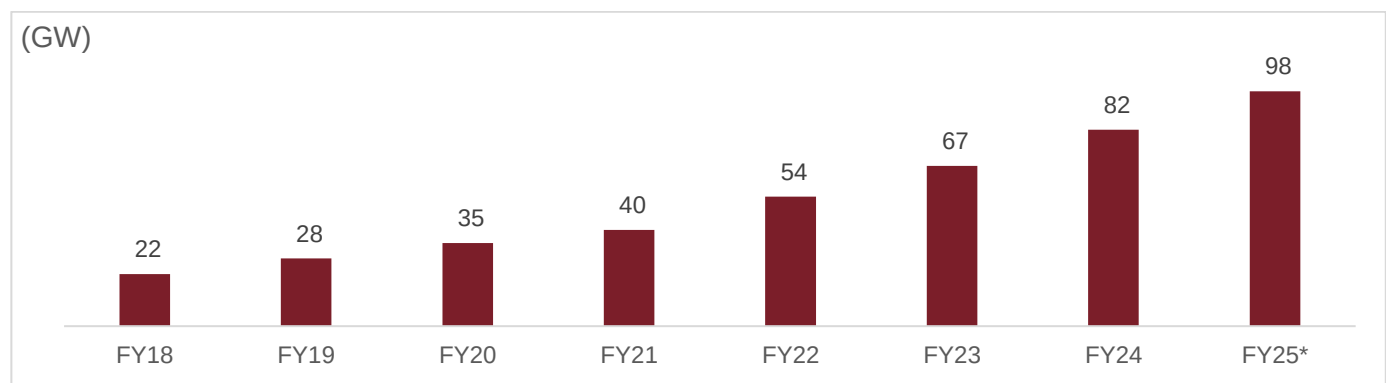
- **Portugal:** As per the “Global Photovoltaic Power Potential by Country Report” by World Bank (June 2020), Portugal has an average theoretical potential of 4.57 kWh/m²/day (GHI). In May 2023, Portugal had an installed capacity of 17.4 GW with hydroelectric power accounting for 8.1 GW, wind for 5.7 GW, solar for 2.7 GW, and approximately 0.9 GW from other sources. Solar PV forms ~16% of the total installed capacity. Portugal has revised its 2030 goals for installation of solar energy capacity and electrolyser capacity for producing green hydrogen. It has revised its climate change plan, aiming to reduce greenhouse gas emissions by 55% by 2030 compared to 2005 levels, which is an increase from its previous target of a 45%-55% cut. According to the government's forecast, the total installed renewable energy capacity is expected to increase to 42.8 GW by 2030, exceeding the previous target of 27.4 GW and more than doubling the current capacity in operation.
- **Europe:** Europe has significant potential for renewable energy, with a diverse range of resources available across the continent. The Countries in Europe are known for their progressive renewable energy initiatives and stringent regulatory frameworks. The revised Renewable Energy Directive EU/2023/2413 raises the European Union's (EU) binding renewable target for 2030 to a minimum of 42.5%, up from the previous 32% target, with the aspiration to reach 45%. The EU solar generation reached an estimated 259.99 GW in 2023. As part of the REPowerEU plan, the EU aims to deliver over 320 GW of solar photovoltaic by 2025 and almost 600 GW by 2030. The wind sector is also a significant contributor to the EU economy, boosting growth and creating long-term sustainable jobs. The EU wind generation has reached an estimated 221 GW in 2023.
- **Southeast Asia:** The Association of Southeast Asian Nations, commonly abbreviated as ASEAN, is a political and economic union of 10 states in Southeast Asia. By the end of 2022, ASEAN had 310 GW of installed power capacity, with coal (106.3 GW), gas (89.6 GW), and hydro (61.2 GW) accounting for the largest shares. Indonesia, Vietnam, and Thailand account for two-thirds of ASEAN's demographics which together also recorded over two-thirds of ASEAN's total installed capacity by 2022. ASEAN has targeted to add 17,465 MW of solar capacity from 2023 to 2025. As per the ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025, ASEAN aims to achieve its targets of 23% share of RE in total primary energy supply and 35% share of RE in ASEAN installed power capacity by 2025 by deploying large-scale renewable energy systems, accommodating higher shares of RE in the APG, increasing RE investments, and exploring new and emerging energy technologies such as hydrogen and fuel cells. The ASEAN region will have 27 GW of solar and 6.8 GW of wind installed capacity in 2022, representing less than 1% of the approximately 30,523 GW of solar and 1,383 GW of wind theoretical potential estimated by the National Renewable Energy Laboratory (NREL). Based on the 6th ASEAN Energy Outlook, the region would need power capacity additions of 479 GW by 2040 as electricity grows at triple the rate of the overall energy demand. Coal and gas will continue to play a strong role, providing additional capacity of 186 GW and 109 GW, respectively, by 2040. Notably, a total of 160 GW capacity additions will come from renewables, especially solar PV, with an additional 51 GW capacity by 2040.
- **Middle East:** To decarbonize the power sector, Middle Eastern countries are focusing on the deployment of renewable energies. Increased population, urbanisation and economic development have accelerated the energy requirement. The Middle East receives some of the highest levels of solar irradiance in the world, with an average of 2,000-2,500 kWh/m² per year. Some of the Middle eastern countries like Saudi Arabia, the United Arab Emirates (UAE), and Qatar receive 2,500-3,000 kWh/m² per year, making them ideal for solar energy generation. Historically, this region has been dependent on fossil fuels for power generation. However, considering the sustainability targets and increased focus on clean energy, many countries in the Region have set ambitious targets for renewable energy additions. The UAE Energy Strategy 2050 aims to triple the

contribution of renewable energy and invest AED 150 to AED 200 billion by 2030 to meet the country's increasing demand for energy as a result of a rapidly growing economy. The target for the 2050 energy mix is as follows: 44% clean energy, 38% gas, 12% clean coal and 6% nuclear energy. Saudi Arabia has committed to having 50% of its power generated from renewable sources by 2030.

3.2 Evolution of Solar Power in India

In the renewable energy basket (including large hydro) as of December 2024, solar energy accounted for a share of ~45%. Growth in the solar power sector over the last five years has been robust. Approximately 76 GW capacity was added in the segment over Fiscals 2018-25 (as of December 2024), registering a CAGR over ~24.0%, although starting from a low base. Despite the second wave of COVID-19 infections, Fiscal 2022 witnessed solar capacity additions of ~14 GW. In a relief to developers, the MNRE provided a total extension of seven-and-a-half months for the projects affected by the first and second waves of the pandemic. This is estimated to have delayed commissioning in Fiscal 2022, leading to a spillover into Fiscals 2023 and 2024. In Fiscal 2023, solar capacity additions stood at ~13 GW, with ~2.2 GW coming from rooftop solar projects. Similarly, in Fiscal 2024, solar capacity additions stood at ~15 GW, with ~3 GW coming from grid connected rooftop solar projects. During the first nine months of Fiscal 2025, ~16 GW solar capacity was added.

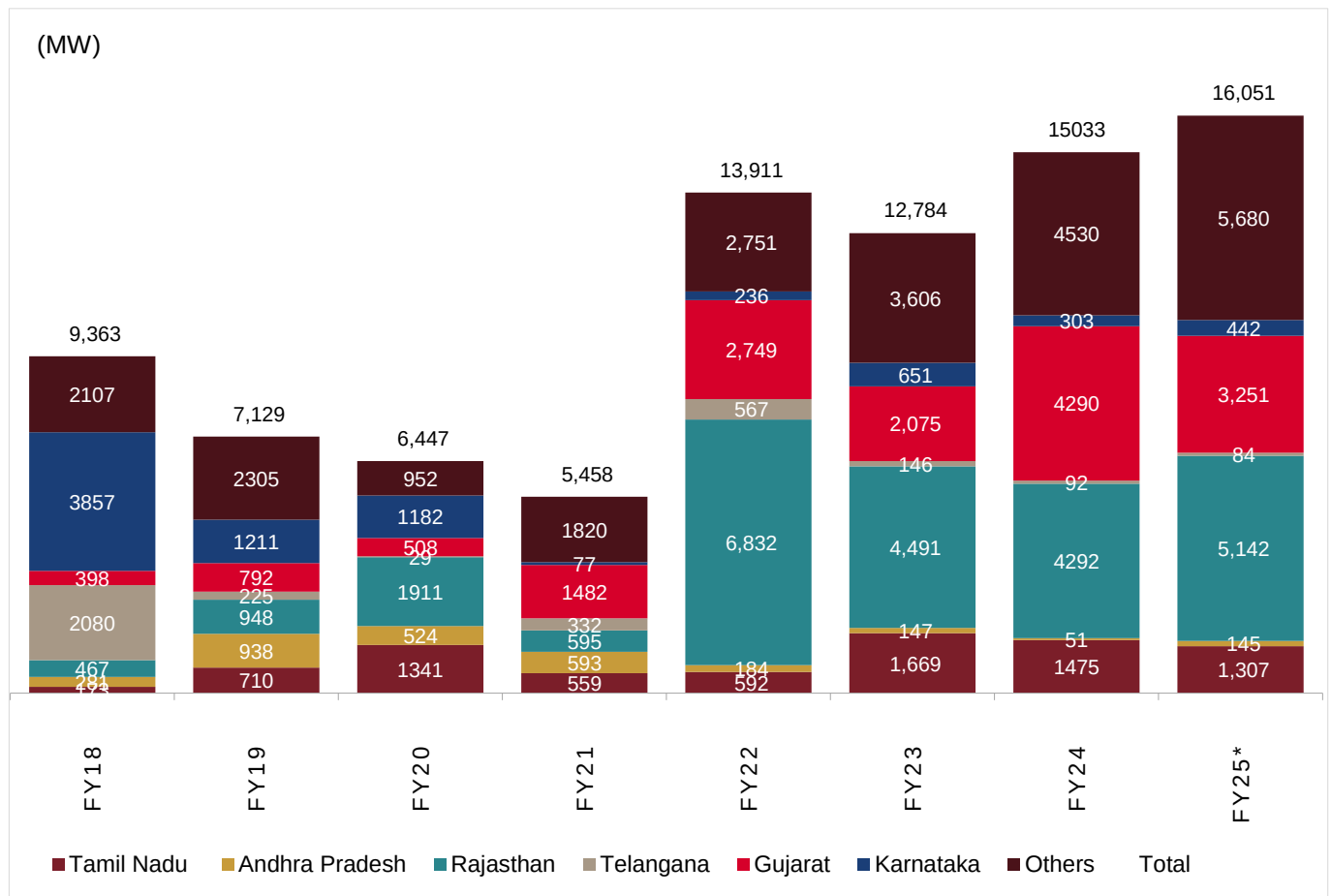
Figure 13: Trend in cumulative solar capacity installation in India



*FY25 as on December 2024; Source: MNRE, CEA, Crisil Intelligence

The imposing of solar RPOs across Indian states in 2011 by GoI, coupled with the sharp drop in capital costs, led most states to release solar policies. This resulted in a spur in solar sector investments. Until Fiscal 2012, only Gujarat and Rajasthan had state solar policies. Following the success of Gujarat's solar policy, other states such as Andhra Pradesh, Tamil Nadu, Karnataka, Madhya Pradesh, and Telangana introduced their respective solar policies.

During Fiscals 2018-2023, ~45 GW of solar capacity has been commissioned, compared with the expected commissioning of 60-65 GW. Despite the second pandemic wave, ~14 GW of solar capacity was added in Fiscal 2022. The momentum continued in Fiscals 2023 and 2024, with robust solar capacity additions of ~13 GW and ~15 GW, respectively.

Figure 14: States that helped drive solar capacity addition in India


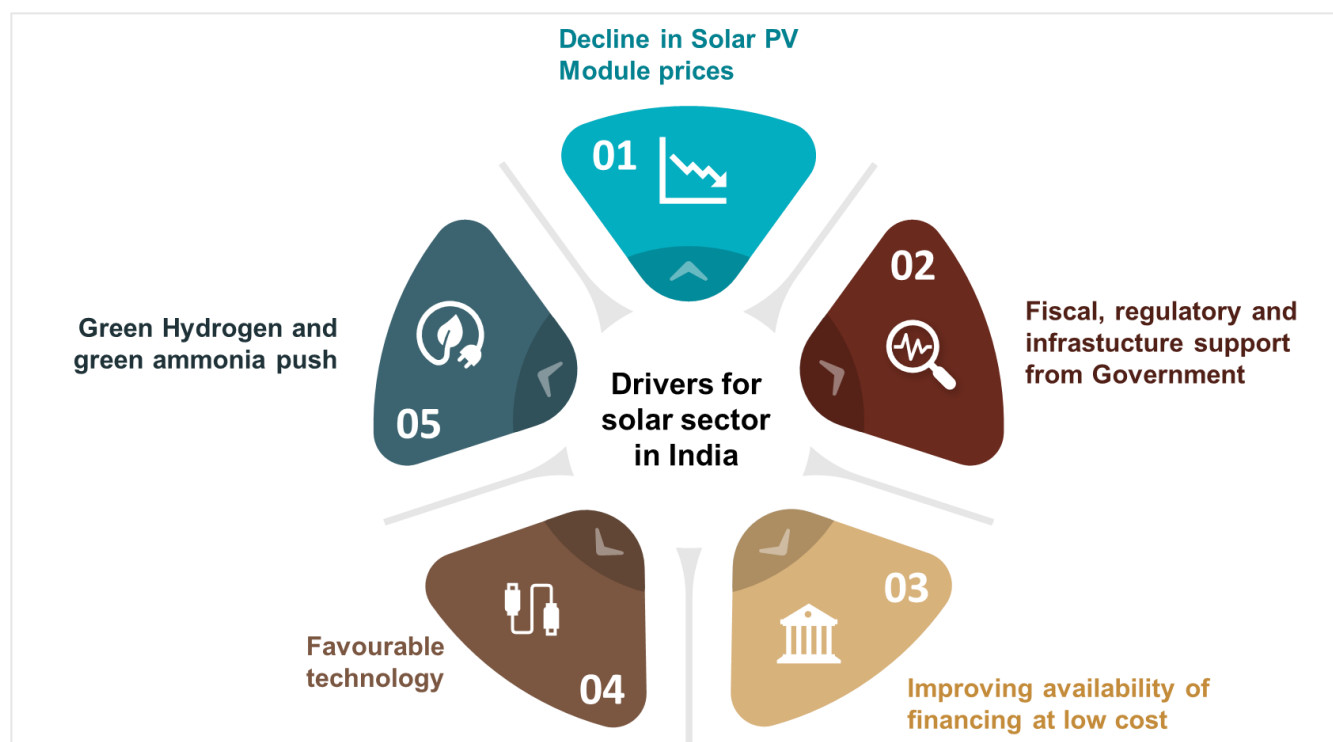
*As of December 2024, Source: MNRE, Crisil Intelligence

States like Gujarat, Rajasthan, Madhya Pradesh, Andhra Pradesh, Karnataka, and Tamil Nadu offer more solar irradiance as compared to other parts of India, which makes them desirable for installing solar projects.

Commissioning activity has been concentrated in key states of Rajasthan, Gujarat, and Tamil Nadu, which accounted for two-thirds of total capacity added in Fiscal 2024. The installation trend was driven by the same states in the previous Fiscal year as well.

3.3 Key drivers for solar energy capacity additions

Figure 15: Growth drivers for solar sector in India



Source: Crisil Intelligence

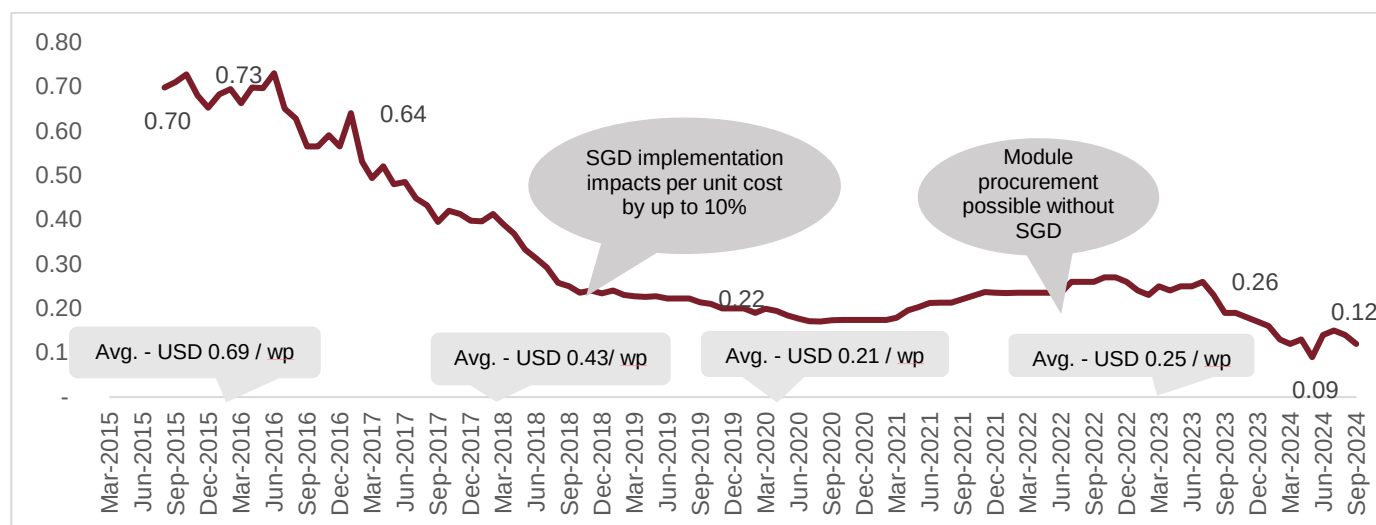
Some of these are discussed in detail in the following sections:

3.3.1.1 Declining module prices and tariffs

The global average solar module price, which constitutes 55-60% of the total system cost, crashed by 73% to \$0.47 per watt-peak in 2016 (average for January-December) from \$1.78 per watt-peak in 2010. In fact, prices continued to decline to \$0.22 per watt-peak by end-August 2019, owing to technological improvement, scale benefits, and a demand-supply gap in the global solar module manufacturing industry. Further, declining inverter prices (6-7% of the capital cost), which fell to \$0.2 per watt-peak by March 2020 (which has now been reduced to \$0.016-0.018 per Wp), reduced system costs. In Fiscal 2021, module prices reached \$0.22 per watt-peak.

Module prices started to fall in 2023, owing to the ramp-up in the production of upstream components. Prices of modules fell to \$0.15-0.20 per watt-peak in April-November 2023 from \$0.23 per watt-peak in January 2023. This has eased some pressure on the capital costs in Fiscal 2024. Prices of Monofacial module had touched USD 0.20 wp by Q4 of Fiscal 2024. Crisil Intelligence expects that after the reapplication of ALMM, the domestic module prices will inch up on a quarterly basis as demand for domestic modules grows. As India largely relies on imported cells for module manufacturing, a steep fall in upstream component prices has also resulted in fall in module prices. Thus, the average price for Fiscal 2025 is expected to remain 24-26% below compared to last Fiscal, owing to low cell prices on year. Crisil Intelligence expects prices to be in the range of USD 0.16-0.18 per Wp for imported mono-crystalline modules and USD 0.17-0.19 per Wp for domestic mono-crystalline modules (assembled using imported cells) in Fiscal 2025, owing to limited room for discounts at the manufacturing level.

Figure 16: Module prices declined over 80-85%% from Fiscal 2010 to 2024 (USD/Wp)



Source: Industry, Crisil Intelligence

Table 3: Safeguard and customs duty trajectory

Year of imposition	July 30, 2018, to July 29, 2019	July 30, 2019, to January 29, 2020	January 30, 2020, to July 29, 2020	July 30, 2020, to January 29, 2021	January 30, 2021, to July 29, 2021	From April 1, 2022 (BCD)	From 2 February 2025 (BCD)*
Duty rate	25%	20%	15%	14.9%	14.5%	Module – 40% Cell – 25%	Module- 20% Cell- 20%

* Additional agricultural and infrastructure development cess of 20% on modules and 7.5% on cells

Source: Crisil Intelligence

Various players from the Indian solar component manufacturing industry filed additional duty petitions against imports. The key in this regard was a safeguard duty investigation filed by the Indian Solar Manufacturer's Association (ISMA) to the Directorate General of Trade Remedies (DGTR).

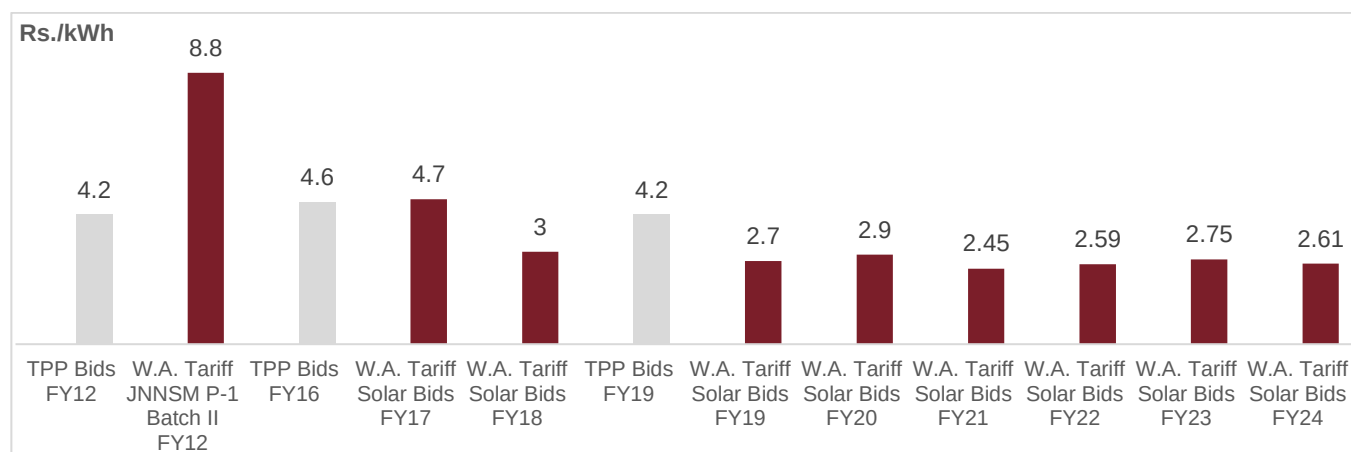
After initiating a probe to decide on the continuation of the Safeguard Duty (SGD) on solar import and receiving applications from domestic companies, the DGTR extended the imposition of the SGD for another year, with the duty being levied at 14.9% from July 30, 2020, to January 29, 2021, followed by 14.5% from January 30, 2021, to July 29, 2021. Declining duty had led to eased cost pressures, and tariffs began to lower. However, the Ministry of Finance imposed a BCD of 25% and 40% on solar cells and modules, respectively, effective April 1, 2022. The imposition of the BCD led to an increase in capital costs for projects based on imported modules by 20-25%, and an increase in tariffs by Rs 0.2-0.5/kWh (with the tariffs ranging from Rs 2.6-2.8/kWh).

In the Budget for Fiscal 2026, the government has reduced the import duties on solar cells to 20% from 25% and solar modules to 20% from 40%, effective May 1, 2025. However, the Agricultural and Infrastructure Development Cess (AIDC) of 20% on modules and 7.5% on cells keep the effective BCD rate of solar modules at 40% and for cells 27.5%.

Solar power tariffs have been lower than coal-based power tariffs

In recent years, there has not been any major development in the case of thermal power bidding. However, considering the previously bid prices of thermal power, solar power tariffs have been on the lower side.

Figure 17: Competitively bid solar power tariffs are much lower than coal-based power tariffs



Note: TPP – Thermal power plant; JNNSM – Jawaharlal Nehru National Solar Mission; W.A. – Weighted average levelized tariffs

Source: Details of Case I bids, Bidding of power from stressed assets, CEA; Crisil Intelligence

However, while looking at solar tariffs, one will have to increasingly factor in grid integration costs as the penetration level of renewable energy increases. This is expected to increase the procurement cost of solar power plants and hence an incremental focus on hybrid and FDRE.

3.3.1.2 Fiscal and regulatory incentives

The Indian government has been offering a variety of incentives to encourage the development of solar power plants.

PM Surya Ghar Muft Bijli Yojna: For further sustainable development and people's well-being, the Central Government in February 2024 launched the PM Surya Ghar: Muft Bijli Yojna. This scheme has a proposed outlay of Rs. 750 billion and aims to light up 10 million households by providing up to 300 units of free electricity every month.

Subsidy for residential households

- Rs. 30,000/- per kW up to 2 kW
- Rs. 18,000/- per kW for additional capacity up to 3 kW
- Total Subsidy for systems larger than 3 kW capped at Rs 78,000

The MNRE on February 20, 2024, has declared that only applications received after February 13, 2024, will be considered for CFA under PM Surya Ghar Muft Bijli Yojana. Further, it was also clarified that this is a whole new scheme, and all previous schemes have been lapsed.

There was a similar scheme in place to encourage solar rooftop installations. However, due to a lack of awareness and clarity on savings, higher capital costs, delays in subsidy reimbursements, approvals and bureaucracy, and subsidized tariffs for lower slabs of electricity consumption, the scheme did not receive success as expected. Lower residential tariffs and higher investments may hinder the progress of the scheme. Further, CPSUs have been entrusted with the residential solar installation under the scheme. The Central government introduced the CPSU scheme Phase I in 2015 to promote the set-up of 1,000 MW grid-connected solar PV power projects by CPSUs and government organisations with Viability Gap Funding (VGF). Further, in March 2019, the Central Government approved the implementation of CPSU Scheme Phase-II for setting up grid-connected Solar PV Power Projects by Central and State PSUs, Government Organisations, with VGF support of Rs 85.8 billion, for self-use or use by Government/ Government entities, either directly or through Discoms. The maximum permissible VGF was initially set in two tranches and was kept at Rs 7 Mn/MW. This was subsequently reduced to Rs 5.5 Mn/MW for the third tranche. Under this Scheme, the Government has so far sanctioned about 8.2 GW capacity of solar PV power plants to various entities. The ability of CPSUs to execute the scheme at ground level and consumer awareness will play key roles in the success of the Scheme.

Annual Bidding Trajectory:

MNRE has prescribed an annual bidding trajectory for RE power bids to be issued by the Renewable Energy Implementation Agencies (REIAs). Bids for 50 GW per annum RE capacity, with at least 10 GW per annum Wind power capacity, are to be issued each year from 2023-24 to 2027-28. This is expected to help in achieving the targets specified for 2030. Bids of 35.51 GW have been issued by four REIAs (SECI, NTPC, NHPC & SJVN) in Fiscal 2024 until December 2023.

The GoI has laid significant emphasis on climate change, for which it provided a framework, NAPCC, in 2008, where it proposed an eight-pronged strategy — NSM, energy efficiency, sustainable habitat, water planning, Himalayan ecosystem, afforestation, sustainable agriculture, and strategic knowledge on climate change. As can be seen, the GoI has laid significant emphasis on solar power. This is also evident from the 100 GW out of 175 GW target set out by the GoI. Government support for the solar sector in India is as follows:

National Solar Mission

Central-level allocations under NVVN Batch II, JNNSM Phase II Batch III and IV have been almost entirely commissioned.

Operational support to execute solar projects

Apart from providing incentives, the government has lent significant support to the solar power sector for the execution of projects.

Solar parks and ultra mega solar power projects: One of the most important initiatives by the GoI has been the establishment of solar parks in the country. To overcome the land, approvals and transmission-related challenges, the scheme for “Development of Solar Parks and Ultra-Mega Solar Power Projects” was rolled out in December 2014 with the objective to facilitate the solar project developers to set up projects expeditiously.

While solar power projects can be set up across the country, projects developed in scattered manner leads to higher project cost per MW and higher transmission losses. Additionally, the process of acquiring land, obtaining various clearances, and securing permissions is time-consuming for project developers, resulting in delays to the project. To overcome these challenges, the Ministry of Power, Government of India, has introduced the Solar Parks Programme with the objective of expediting the development of solar projects nationwide. The Solar Parks Programme is intended to enable solar project developers to set up projects based on a plug-and-play model, offering an efficient framework for the establishment of solar parks. A solar park is a large chunk of land developed with common infrastructure facilities like transmission infrastructure, road, water etc. with all statutory clearances. Thus, solar project developers can set up solar projects in a hassle-free manner. Solar parks can be developed through collaboration with state designated nodal agencies, State PSU, a SPV of state government, CPSUs, or private entrepreneurs.

This is critical given the land-intensive nature (~3-5 acres required per MW of solar PV depending on module size) of solar projects, coupled with low average landholding (1.16 hectare) per person in India. The standalone solar power projects spread across the country may incur higher costs per megawatt and increased transmission losses. Additionally, the lengthy procedures involved in acquiring land, obtaining clearances, and securing permissions cause significant delays for developers. In response to these challenges, the Ministry of Power, Government of India, has initiated the Solar Parks Programme, which aims to streamline the development of solar projects nationwide.

Under the Solar Park Policy released in September 2014, the government planned to prepare land banks for 20,000 MW of solar projects across 25 states (including Andhra Pradesh, Madhya Pradesh, Gujarat, Rajasthan, Uttar Pradesh, Karnataka, Telangana, West Bengal, Chhattisgarh, Tamil Nadu, Jammu and Kashmir, and a few north-eastern states). These states have started preparing land banks for solar parks, either through their own implementing agencies or through joint ventures with SECI.

The capacity of the scheme was doubled from 20,000 MW to 40,000 MW in March 2017, to set up at least 50 solar parks by Fiscal 2022. Such parks significantly reduce construction/ execution risk as they include a contiguous parcel

of land, evacuation infrastructure (HV/EHV substation evacuating to state grid substation), and other ancillary infrastructure and utilities such as road, water, and drainage.

Solar Parks / UMREPPs of aggregate capacity of 40,763 MW have been envisaged for development in the country as on 31st December 2024. Of these, the capacity of 12,306 MW has already been commissioned while 13,030 MW capacity is under construction and 15,177 MW is under award/tendering process. The State-wise details are given below.

Table 4: State wise solar park approved capacity (GW) as of December 2024

Sr. No.	Name of the State in which Solar Parks/UMREPPs are located	Total Capacity of Solar Park/ UMREPP (MW)	Capacity Under Award / Tendering (MW)	Capacity Awarded (MW)	Capacity Under construction (MW)	Capacity Commissioned (MW)
1	Andhra Pradesh	4,300	-	4,300	1,250	3,050
2	Chhattisgarh	100	-	100	-	100
3	Gujarat	12,150	3,770	8,380	7,380	1,000
4	Himachal Pradesh	53	21	32	-	32
5	Jharkhand	1,089	679	410	410	-
6	Karnataka	2,500	500	2,000	-	2,000
7	Kerala	255	100	155	50	105
8	Madhya Pradesh	4,780	2,002	2,778	515	2,263
9	Maharashtra	1,105	605	500	250	-
10	Mizoram	20	-	20	-	20
11	Odisha	340	200	140	140	-
12	Rajasthan	10,341	6,000	4,341	1,035	3,306
13	Uttar Pradesh	3,730	1,300	2,430	2,000	430
	Total	40,763	15,177	25,586	13,030	12,306

Source: CEA, MNRE, Crisil Intelligence

Other Policy/Regulatory initiatives

- Implementation of Electricity (Promoting Renewable Energy Through Green Energy Open Access) Rules, 2022
- The MoP, in August 2020, waived the ISTS charges and losses on all solar and wind projects commissioned before June 30, 2023. In June 2021, the waiver was extended up to June 30, 2025. However, this time, only the ISTS charges were waived, and losses remained applicable. Waivers are available for projects commissioned by June 30, 2025. However, post June 2025, an annual increase of 25% in the ISTS charges will be applicable for solar, wind, hydro PSP, and BESS sources, resulting in the applicability of 100% of ISTS charges from July 2028. Subsequently, in February 2023, it was clarified that green hydrogen and green ammonia projects would get a waiver of ISTS charges for 25 years if the projects are commissioned before June 30, 2025.
- The MoP further decided to extend the waiver of ISTS charges on the transmission of power from new hydro power projects, for which, construction work is awarded and PPAs are signed on or before June 30, 2025.
- Captive power projects are exempt from paying cross subsidy surcharge (CSS), as per Section 42(2) of the Electricity Act 2003. In its judgement dated December 10, 2021, the Supreme Court ruled that captive power consumers are not liable to pay an additional surcharge under Section 42 (4) of the Electricity Act, 2003.

Regulations and policies governing the solar power or power utilities can present technical, regulatory or economic barriers to the setting up of solar power projects and the purchase and use of solar energy.

3.3.1.3 Favourable technology

Solar power is becoming increasingly attractive due to falling module prices and improving efficiency resulting from excess manufacturing capacity in China and technological advancements, respectively.

On the project development front, developers are exhibiting a heightened preference for bifacial modules that are compatible with tracker technology and typically have higher efficiency relative to mono-facial modules. In 2023, the share of bifacial variants in module imports increased from 8% in Q1 2022 to 40% in Q1 2024. On the other hand, multi-crystalline modules are being phased out due to lower efficiency and higher degradation rates. The share of import volume was negligible in 2023.

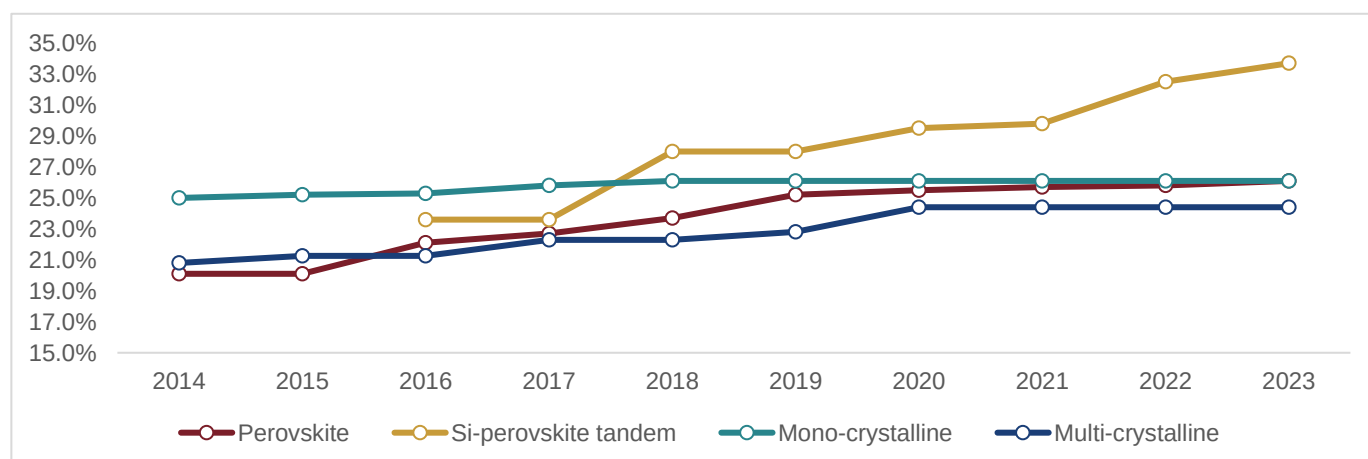
The share of monocrystalline technology is now about 84% (compared with 66% in 2019) of total crystalline silicon (c-Si) production. The performance ratio has also been improved in the 80-90% range. The c-Si segment is expected to grow substantially due to c-Si's long life and light weight.

Currently, the solar PV market is dominated by monocrystalline silicon technology. Within monocrystalline technology, Mono PERC is an advanced version that employs dielectric passivation film on the rear surface of the cells which increases the efficiency levels. These cells are currently leading the market due to higher efficiency, less space covered, higher output in low light conditions and are available at competitive pricing. However, ongoing technological innovation in the manufacturing processes is crucial to reduce material intensity, especially for critical minerals like silver and copper. These efforts aim to minimize vulnerabilities in the supply chain.

In addition to process improvements, the development of new solar cell designs is essential for achieving further efficiency gains while simultaneously reducing material intensity and manufacturing costs. The p-type to n-type migration is currently underway and paving the way for new technologies – by the end of 2023, n-type technologies including TOPCon, heterojunction (HJT) and back contact represented 42% of China's total module manufacturing capacity (7% in 2022). These designs hold the potential for achieving additional efficiency gains in solar panels. Based on pilot tests conducted by leading global manufacturers, it is estimated that the TOPCon cell could provide an additional efficiency gain of up to 2-2.5% gain over mono PERC modules. Even though TOPCon is expected to be the dominant n-type technology over the next couple of years due to its lower cost over other new technologies, HJT modules' higher efficiency, and lower temperature sensitivity make it a better alternative to TOPCon modules in selected locations. Additionally, China's market share of HJT modules is expected to increase from an estimated 2% in 2023 to around 16% in 2027 due to decreasing production cost differential with TOPCon technology.

In addition, there are ongoing considerations for mass manufacturing of multilayer and tandem silicon-perovskite or silicon-CdTe hybrid solar panels. These innovative solutions have the potential to significantly increase cell efficiency, surpassing the 30% mark, while maintaining competitive production costs and promise to make solar power an even more compelling and sustainable energy solution in the years to come.

Figure 18: Cell efficiency comparison



Source: NREL, Crisil Intelligence

3.4 Review of policies

3.4.1 Key incentives for various solar schemes

Sr. No.	Scheme	Incentives
1.	Grid Connected Rooftop Solar PV Power Projects PM Surya Scheme	Subsidy for residential households - Rs. 30,000/- per kW up to 2 kW - Rs. 18,000/- per kW for additional capacity up to 3 kW - Total Subsidy for systems larger than 3 kW capped at Rs 78,000
2.	Central Public Sector Undertaking (CPSU) Scheme Phase-II	Viability Gap Funding (VGF) support up to Rs 5.5 Mn per MW to the CPSUs/Govt. Organizations entities selected through competitive bidding process.
3.	PLI Scheme 'National Programme on High Efficiency Solar PV Modules'	The beneficiaries are eligible for Production Linked Incentive (PLI) on production and sale of solar PV modules. The quantum of PLI eligible for disbursal depends upon: (i) quantum of sales of solar PV modules; (ii) performance parameters (efficiency and temperature coefficient of maximum power) of solar PV modules sold; and (iii) percentage of local value addition in modules sold.
4.	Solar Park Scheme	- Up to Rs. 2.5 million per Solar Park, for the preparation of Detailed Project Report (DPR). - Rs. 2.0 million per MW or 30% of the project cost, whichever is lower, for development of infrastructure.
5.	PM-KUSUM scheme	Component A: Setting up of 10,000 MW of Decentralized Ground/Stilt Mounted Solar Power Plants - Benefit available: Procurement Based Incentive (PBI) to the DISCOMs @ 40 paise/kWh or Rs.0.66 Mn/MW/year, whichever is lower, for buying solar power under this scheme. The PBI is given to the DISCOMs for a period of five years from the Commercial Operation Date of the plant. Therefore, the total PBI payable to DISCOMs is up to Rs. 3.3 million per MW. Component B: Installation of 2 million Stand-alone Solar Pumps Benefit available: CFA of 30% of the benchmark cost or the tender cost, whichever is lower, of the stand-alone solar agriculture pump is provided. However, in Northeastern States, Sikkim, Jammu & Kashmir, Ladakh, Himachal Pradesh and Uttarakhand, Lakshadweep and A&N Islands, CFA of 50% of the benchmark cost or the tender cost, whichever is lower, of the stand-alone solar pump is provided. Component C: Solarisation of 1.5 million Grid Connected Agriculture Pumps including through feeder level solarisation Benefit available: a. Individual Pump Solarization: CFA of 30% of the benchmark cost or the tender cost, whichever is lower, of the solar PV component will be provided. However, in Northeastern States, Sikkim, Jammu & Kashmir, Ladakh, Himachal Pradesh and Uttarakhand, Lakshadweep and A&N Islands, CFA of 50% of the benchmark cost or the tender cost, whichever is lower, of the solar PV component is provided. b. Feeder Level Solarization: Agriculture feeders can be solarized by the State Government in CAPEX or RESCO mode with CFA of Rs. 10.5 Mn per MW as provided by MNRE. However, in Northeastern States, Sikkim, Jammu & Kashmir, Ladakh, Himachal Pradesh, Uttarakhand, Lakshadweep and Andaman & Nicobar Island, CFA of Rs. 17.5 Mn per MW is provided.
6.	Green Energy Corridor Scheme (for development of intra-state transmission system for RE projects)	- GEC Phase-I: CFA of 40 % of DPR cost or awarded cost, whichever is lower. - GEC Phase-II: CFA of 33 % of DPR cost or awarded cost, whichever is lower.

Sr. No.	Scheme	Incentives
7.	R&D programme	MNRE encourages research and technology development proposals in collaboration with the industry and provides up to 100% financial support to Government/non-profit research organizations and up to 50- 70% to Industry, Start-ups, Private Institutes, Entrepreneurs and Manufacturing units.
8.	National Green Hydrogen Mission	- SIGHT programme for Electrolyser manufacturing: allocation of Rs. 44.40 billion by 2029-30; incentives start from Rs. 4440 per kW in the first year and end at Rs. 1480 per kW in the fifth year. - SIGHT programme for Green Hydrogen production (Mode-I): incentives for Green Hydrogen production, which are capped at Rs. 50/kg Rs. 40/kg and Rs. 30/kg for the first, second and third year, respectively.
9.	Other Tax benefits	Income tax exemption for solar power projects like Section 80-IA of the Income Tax Act, 1961, Accelerated Depreciation (AD), and GST exemptions.

Source: MNRE, Industry, Crisil Intelligence

3.4.2 State level key policy provisions

- Gujarat:** State regulator has adopted green OA regulation in line with MOP directions. The state has removed size cap on solar projects and increased banking duration from daily to monthly. Gujarat allows net metering arrangement without any restrictions on business model and in parallel with other routes like open access. 100% waiver on additional surcharge. 25% waiver on CSS and additional surcharge for third-party sale projects. Wheeling charges and losses exempted for rooftop solar.
- Andhra Pradesh:** State regulator has adopted green open access regulation in line with directions from the MoP. Revision in banking charges from 2% to 8%. Unutilised banked power to be compensated at 75% of tariff discovered in previous SECI auction. Andhra Pradesh is among the few major states that still offer net metering to C&I consumers without any restrictions on business model. System size limit has been set at 500 kW and 1 MW under net metering and net billing respectively.
- Tamil Nadu:** Tamil Nadu is the only RE-rich state that continues to offer attractive incentives on grid charges to OA consumers. State offers Waiver on network charges for rooftop solar in following manner. 50% for MSME consumers; 80% for residential consumers with system size up to 10 kW and 25% for residential consumers with system size over 10 kW.
- Maharashtra:** MERC adopted MOP's Green OA Rules in November 2023 addressing several challenges faced by market participants under previous regulatory framework. While MOP Rules put a cap on banked power up to 30% of monthly consumption from DISCOM, MERC has placed no cap on volume of banked power. The amendment also removes all restrictions on utilisation of banked power during specific months, as was the case under previous regulatory framework. For rooftop solar, the regulator also deferred levy of grid support charges, wheeling charges and losses until total rooftop solar capacity in the state reaches 5 GW.

The solar power industry is heavily influenced by government rules, regulations and policies, as well as policies adopted by the State Regulatory Commissions. The Government of India and other government agencies have historically provided subsidies and incentives to solar and other RE developers. These subsidies and incentives have been primarily in the form of preferential tariffs for solar projects under long-term power purchase agreements, project cost subsidies, exemptions in open access charges such as cross subsidy surcharge, additional surcharge transmission and wheeling charges and provision of banking facilities, generation-based incentive schemes, accelerated depreciation, tax incentives, tax holidays, and other incentives to end-users, distributors, system integrators and manufacturers of solar energy products. However, these government incentive programs are expected to gradually decrease in scope or be discontinued as solar power technology improves and becomes more affordable relative to other types of energy.

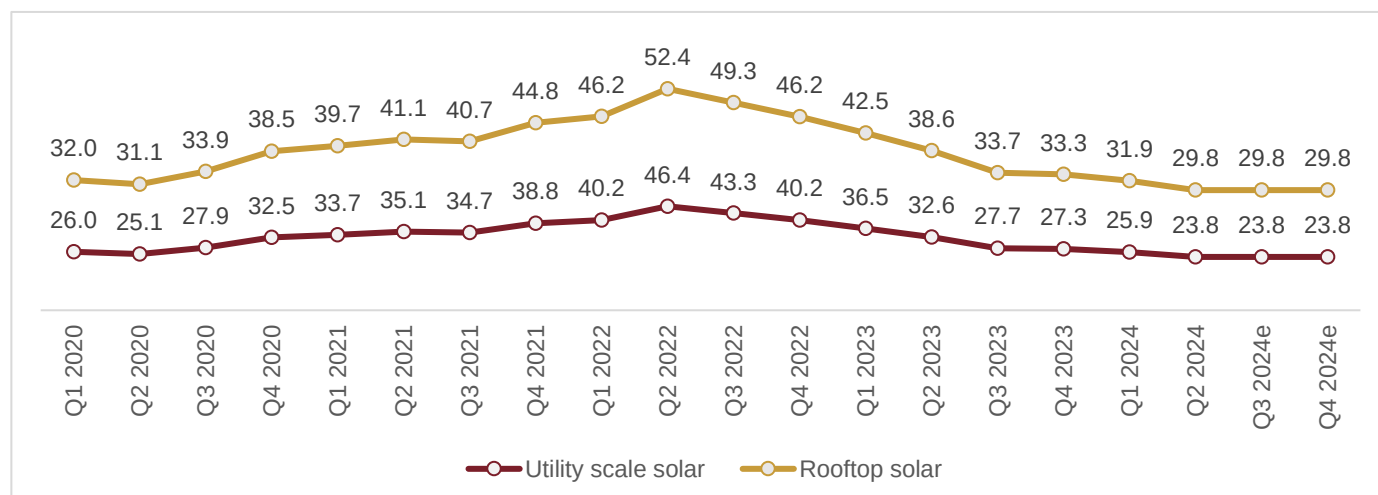
Other factors that could affect the demand for new solar power projects in India, include but are not limited to:

- Cost-effectiveness, performance and reliability of solar power compared to other energy sources;

- Availability of grid to dispatch power generated from solar power projects;
- Public perceptions of the direct and indirect benefits of adopting RE technology;
- Availability of suitable storage solutions for solar energy to ensure continuous and reliable energy supply;
- Price volatility of solar power equipment such as modules, inverters, trackers and transformers;
- Fluctuations in economic and market conditions that could affect the viability of traditional and other alternative energy sources, such as increases or decreases in the prices of oil and other fossil fuels;
- Decrease in capital expenditures by end-users of solar power projects;
- Availability of land for acquisition or lease for project development, as well as the transmission infrastructure for power evacuation;
- Success of other alternative energy generation technologies, such as wind, fuel cells, nuclear, hydrogen;
- Seasonality and favourability of weather conditions impacting installation of solar power plants and resultant generation;
- Cost of capital and availability of credit, loans and other forms of financing for solar power projects etc.;

3.5 Project Capex, EPC and O&M costs movement

Figure 19: EPC cost, Rs million/ MWp



E: Estimated; Source: Industry, Crisil Intelligence

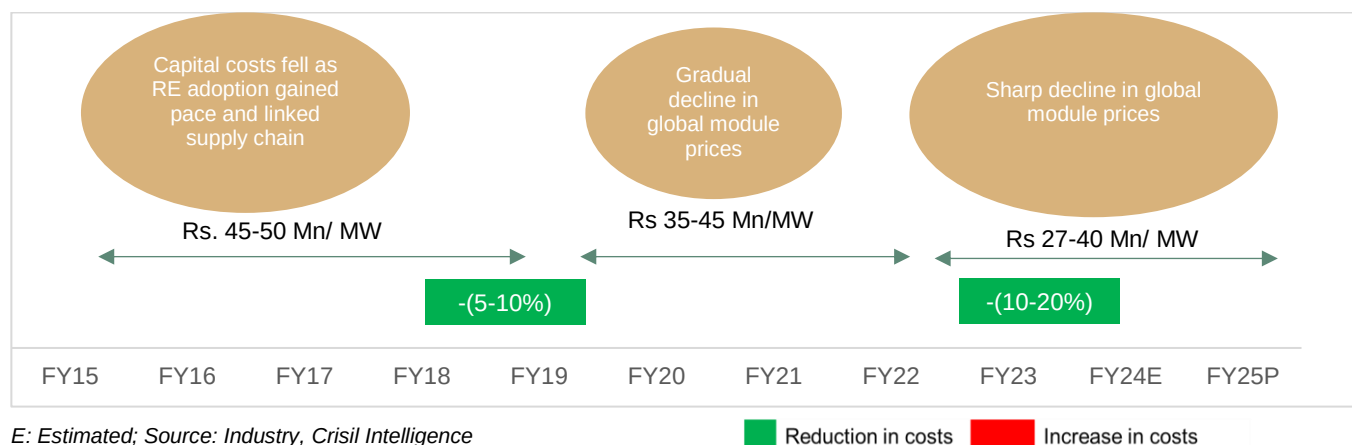
Note: EPC cost for utility scale projects is estimated using imported mono-crystalline modules in a fixed tilt layout and central inverters. EPC cost for rooftop solar systems is estimated for a typical industrial installation on a metal roof.

Solar project CAPEX trend has largely followed global module price trends – between 2011 and 2021, EPC cost for utility-scale projects reduced by around 65% to Rs ~39 million/MWp due to falling module prices. While landed module cost increased temporarily in Q2 2022 due to the imposition of BCD on China modules, over H2 of 2022 and 2023, led by a massive supply glut in China, prices across the solar value chain declined sharply – China module prices decreased by around 57% in the two-year period ended December 2023 to USD 0.12/Wp. As a result, EPC cost for utility-scale projects declined by around 33% in the two-year period ended December 2023 to Rs 27 million/MWp. On the BoS front, while prices of commodities like copper and aluminium (used for building mounting structures and other key components) are volatile, the effect on overall EPC cost is marginal due to a low share in CAPEX.

Going forward, while China module prices are expected to remain soft due to excess manufacturing capacity coupled with subdued international demand (mainly due to US aversion to China imports and high inventory levels in EU), domestic prices are expected to hover around USD 0.18-0.21/Wp in 2024 due to inadequate, albeit growing, domestic supply and ALMM's implementation from April 2024 onwards. On the O&M front, costs have decreased by around 30% in the last 3-4 years to around Rs 0.18-0.25 Mn/MW/annum due to experience gained by service providers

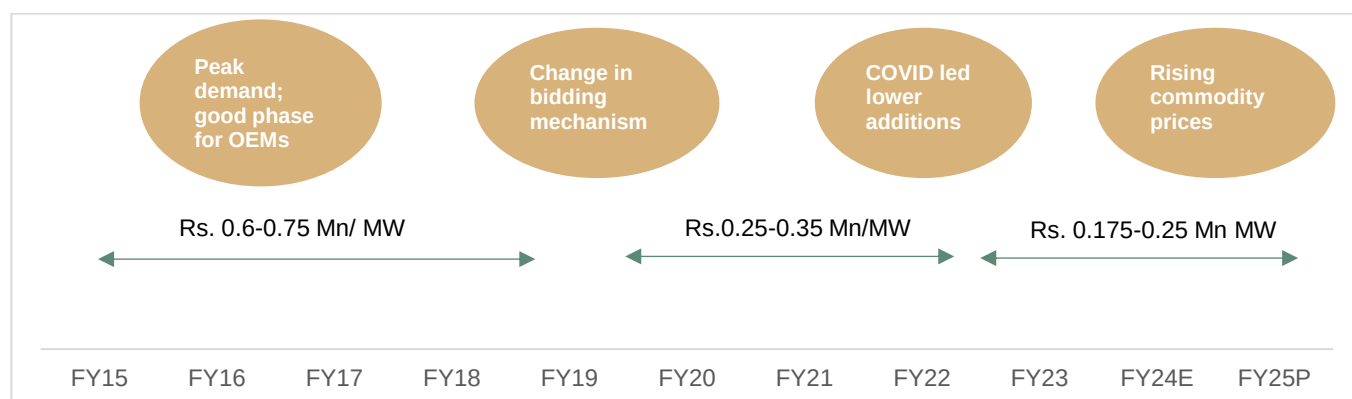
coupled with technology adoption including robotic cleaning. Robotic cleaning not only helps in achieving better efficiency but also is more environmentally friendly since it uses less water and no chemical cleaners.

Figure 20: Declining Module prices leading to lower capital costs



E: Estimated; Source: Industry, Crisil Intelligence

Figure 21: Demand, experience and technological improvement leading to lower annual O&M costs



E: Estimated

Source: Industry, Crisil Intelligence

3.6 Outlook of overall grid-connected solar energy capacity additions

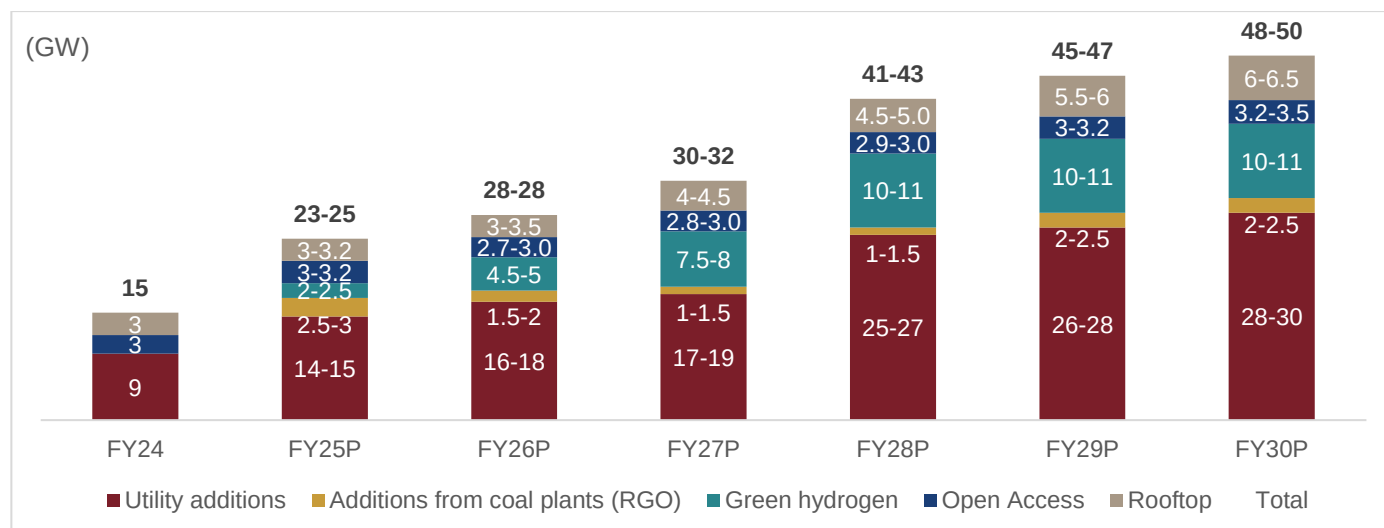
The demand for renewable energy in India is rapidly growing, fueled by environmental considerations and regulatory support. Particularly in the industrial and commercial sectors, there is increasing adoption of group captive and third-party solar models to enhance sustainability and reduce operational costs. Solar sector growth in India primarily spurred by robust government backing, demonstrated through an aggressive tendering strategy. Some of the key catalysts include technological advancements, affordable financing, supportive policies, thrust on go-green initiatives/sustainability targets, cost optimisation due to increased grid electricity tariffs, subsidy initiatives (especially in rooftop solar) and various incentives such as ISTS charge waiver.

Crisil Intelligence expects 175-180 GW of solar capacity additions over Fiscal 2025-2030. This will be driven by the additions under:

- **NSM:** The entire NSM Phase II Batch II Tranche I of 3,000 MW has been commissioned. Under NSM Phase II, Batch III, and Batch IV, SECI through its state specific VGF has tendered out ~7 GW of capacities, most of which has been completed.

- **Other central schemes:** SECI has also started tendering projects outside the JNNSM Batch programme. It has initiated the ISTS scheme, wherein projects are planned for connection with the ISTS grid directly. Under this, SECI has already tendered and allocated ~35 GW (including hybrid).
- **State solar policies:** ~25-27 GW of projects are under construction and are expected to be commissioned over the Fiscal 2025-2030. Based on tendered capacities by states at the end of September 2024, a further ~29 GW capacity of solar projects is expected to be up for bidding over the same duration.
- **PSUs:** The CPSU programme under JNNSM has been extended to 12 GW in February 2019. The government is also encouraging cash-rich PSUs to set up renewable energy projects. NTPC has already commissioned a total of over ~3.7 GW MW of capacities (As of September 2024). It has a target of installing ~35 GW of renewable energy capacities by Fiscal 2028. Similarly, NHPC had allocated ~2 GW of projects in 2020, while the Indian Railways has committed to 20 GW of solar power by 2030. Other PSUs such as NLC, defence organizations, and governmental establishments are also expected to contribute to this addition.
- **Rooftop solar projects:** Crisil Intelligence expects 23-25 GW of rooftop solar projects (under the capex and opex mode) to be commissioned by Fiscal 2030, led by PM Surya Ghar Yojana and industrial and commercial consumers under net/gross metering schemes of various states.
- **Open-access solar projects:** Crisil Intelligence expects 18-19 GW of open-access solar projects (under the capex and opex mode) to be commissioned by Fiscal 2030, led by green energy open access rules 2022, sustainability initiatives/RE 100 targets of the corporate consumers, better tariff structures and policies of states such as Uttar Pradesh and Karnataka, which are more long term in nature.
- **Push for Green hydrogen:** Production for green hydrogen is expected to start from Fiscal 2026 with production of 0.5-1 million tonnes. The government has set the target production of 5 million tonnes of green hydrogen by 2030. As per the announcement, we expect 2.0-2.2 MTPA of green hydrogen to commission, which can lead to the further upside of the solar capacity of 38-40 GW, by Fiscal 2030. However, since developers may tie-up via grid or open access rather than the captive route, generation under this segment will remain monitorable.

Figure 22: Year wise expected solar capacity addition



Source: Crisil Intelligence

Also, global conglomerates such as Amazon, and Microsoft have set their sustainability goals and procured more and more renewable energy in India to set off their global GHG emission. This also provides a lucrative opportunity for IPPs to sign PPAs for RE capacity. A 100 MW solar plant enables a reduction of 1,77,100 tCO₂e (with 22% capacity utilization factor and a combined margin of 0.919) which is equivalent to planting approximately 0.71 million trees (with an average carbon sequestration of 25 kg per tree).

The European Unions' (EU) Carbon Border Adjustment Mechanism (CBAM) is the EU's tool to put a fair price on the carbon emitted during the production of carbon-intensive goods that are entering the EU, and to encourage cleaner industrial production in non-EU countries. The CBAM is expected to have a significant impact on solar capacity additions in non-EU countries. With the increasing adoption of solar energy, CBAM is expected to contribute to the overall growth of the market. The CBAM is expected to drive the renewable energy demand for energy-intensive industries export their products to the European markets in order to follow their norms regarding carbon emission and avoid imposition of penalties for non-adherence to such rules & regulations. Countries in Europe are known for their progressive renewable energy initiatives and stringent regulatory frameworks

Crisil Intelligence's outlook factors in the prevailing market dynamics, where regulatory/policy support is key. The renewable energy domain is highly dependent on policy support, and any uncertainty surrounding this could restrict capacity additions.

3.7 Outlook on rooftop solar PV capacity additions

3.7.1 Grid connected rooftop capacity stood at ~15.7 GW as of December 2024

Rooftop projects are small-scale PV installations on roofs of buildings. Rooftop projects may or may not be connected to the grid.

The government had proposed to achieve 100 GW of solar energy by Fiscal 2022, of which 40 GW was proposed to be added under rooftop-based solar systems. This was extended to Fiscal 2026. However, it is estimated that ~ 15.7 GW of rooftop capacity was installed until December 2024, with ~3.8 GW added in the nine months of Fiscal 2025 against ~2.2 GW in the nine months of the previous Fiscal year. Additions are seen across Gujarat (36%), Kerala (8%), and Maharashtra (20%). While additions in Gujarat and Maharashtra were driven through Surya Urja Yojana 2023 scheme, Kerala presents an opportunity for additions with large roofs per capita. The expansion of the market can be attributed to several factors, including increased consumer awareness, advancements in technology, and proactive subsidy initiatives implemented by both central and state governments. Additionally, global solar module prices reached a historic low of USD 0.18 per watt-peak in June 2024, which is expected to stimulate growth in solar power capacity.

Crisil Intelligence estimates that 25-30% of the installed base was residential, while the remaining was corporate. The residential segment, which lagged in the past, is now on the cusp of expansion. In January 2024, a boost was provided to residential rooftop segment with the launch of PM Surya Yojana which aims to solarise 10 million households.

Further, state initiatives such as Telangana State Renewable Energy Development Corporation Ltd.'s (TSREDCO) aims to install solar panels on 500 school buildings, promoting decentralized electricity generation and mitigating power shedding issues in the state, are contributing to the sector's growth in various regions of India. Fiscal 2024 marked a record year with 2.9 GW of additions driven by Gujarat and Karnataka.

From a pan-India perspective, several roadblocks hinder the growth of the segment. These include the higher cost of rooftop projects compared to utility-scale projects, limited availability of finance for rooftop projects, lack of uniform policies across the states, weak infrastructure of power distribution companies, divergence between state policies and the regulatory commission, and cheaper solar power available from ground-mounted projects.

Although the Ministry of New and Renewable Energy (MNRE) has entrusted the Solar Energy Corporation of India (SECI) with the implementation of large-scale, grid-connected rooftop PV projects, with subsidy support from the National Clean Energy Fund (NCEF), the release of subsidy has been delayed by more than six months in some cases.

Nevertheless, rooftop solar projects have attracted interest from players in the entire solar value chain, ranging from module manufacturers (Tata Power Solar, Waaree Energies, Vikram Solar, etc.) to system integrators (Rays Power, Jakson Engineers) and independent power producers (Welspun Solar, Azure Power, SunEdison, Mahindra Solar,

etc.) owing to falling costs and favorable regulatory policies in key states (net metering, exemption on electricity duty, wheeling and cross-subsidy charges).

PM Surya Ghar Yojna: In order to further sustainable development and people's well-being, the Central Government in February 2024 launched the PM Surya Ghar: Muft Bijli Yojna. This project is expected to add Rs. 750 billion investment and aims to light up 10 million households by providing up to 300 units of free electricity every month.

Subsidy for residential households

- Rs. 30,000/- per kW up to 2 kW
- Rs. 18,000/- per kW for additional capacity up to 3 kW
- Total Subsidy for systems larger than 3 kW capped at Rs 78,000

The MNRE on February 20, 2024, has declared that only applications received after February 13, 2024 will be considered for CFA under PM Surya Ghar Muft Bijli Yojana. Further, it was also clarified that this is a whole new scheme, and all previous schemes have lapsed.

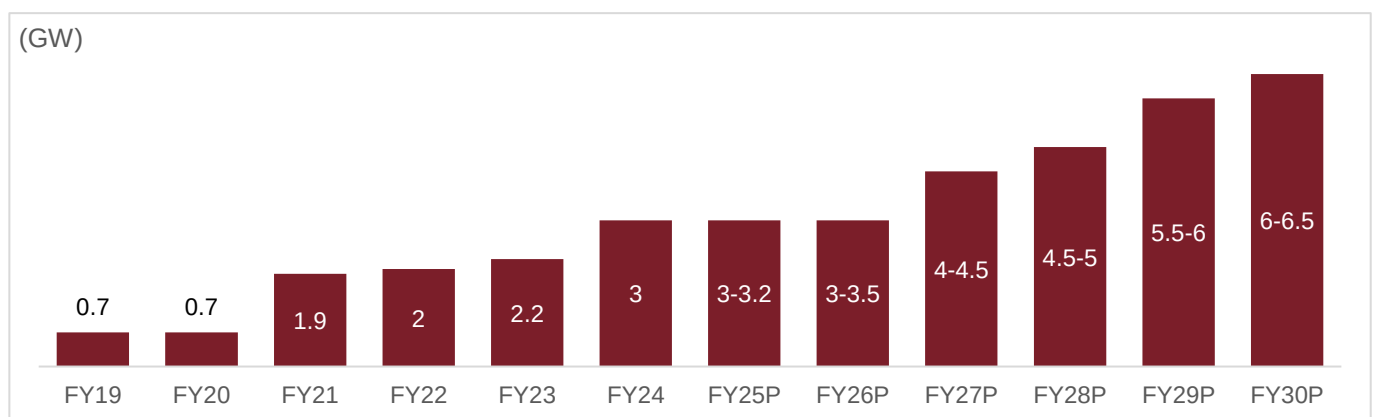
This scheme is expected to boost 20-25 GW of residential rooftop additions, taking the installed base to 22-27 GW from 2.65 GW in Fiscal 2024. Crisil Intelligence expects 10-12 GW to be added between Fiscal 2025 and 2030. The remaining 11-13 GW addition under the scheme presents a potential upside and remains achievable.

3.8 Outlook on rooftop solar PV capacity additions in India

Rooftop solar additions of 23-25 GW expected over Fiscals 2024-2030

Crisil Intelligence expects 23-25 GW of projects to be commissioned, led by the commissioning of capacities by SECI, capacities allocated by state governments, capacities by government institutions, and capacities to be added by industrial and commercial consumers under net/gross metering schemes of various states. Residential rooftop consumers will also contribute to the growth. The Prime Minister's household scheme, if effectively implemented, can boost the residential segment offtake substantially.

Figure 23: Projected rooftop capacity additions over Fiscals 2025-2030



P: Projected

Source: MNRE; Crisil Intelligence

3.9 Outlook on C&I solar capacity addition in India

The C&I users consume ~51% of the electricity generated in India, but only a small percentage of their energy procurement comes from renewable energy sources. C&I users have emerged as an important standalone business segment in recent years in the renewable energy market, indicating their huge untapped potential. Although the present market size is small, specialised developers catering to C&I consumers have emerged with innovative

business models and competitive prices. The growing preference for renewable energy in C&I will drive solar capacity expansions and is expected to grow at a CAGR of 9-10% over Fiscal 2024 to Fiscal 2030. The C&I segment already accounts for 70-80% of the country's rooftop solar installations and is making headway in the utility-scale solar space as well through open access and group captive routes. Further, given that the C&I segment consumes over half of the country's electricity supply, their growing preference for renewable energy will drive solar capacity expansions.

Third-party and group captive solar projects involve IPPs operating solar power plants to generate electricity, which is sold to various consumers in terms of PPAs they enter into. The group captive and third-party models involve long-term contracts, which assures a steady and predictable stream of cash flows over a project's lifespan. These models empower the private sector to finance projects and enable them to reap the benefits of the completed project without the need to bear the initial financial burden. Further the inherent structures of the group captive and third-party models enable higher profit margins compared to traditional project delivery model due to long term strategic financing approach.

Under the group captive model, special purpose vehicles (SPVs) and the customers typically enter into a PPA with a tenure of 25 years and a fixed tariff. The long-term PPA includes a lock-in period, and a clearly defined billing and payment mechanism aimed at minimizing credit risks). Additionally, it encompasses provisions for captive user equity contribution in the SPV and guarantees a minimum off-take, where the consumer commits to purchasing a minimum amount of electricity generated by the SPV over the contract period. Further, there are provisions for compensating the SPV for non-utilization of the generated power. In India, as per the Electricity Act 2003 and subsequent rules and regulations, the group captive route mandates that consumers own a minimum of 26% equity in the generating company and procure at least 51% of the power generated. Through this arrangement, consumers are exempt from paying two significant types of open access charges: cross subsidy surcharge and additional surcharge.

These models empower the private sector to finance projects and enable them to reap the benefits of the completed project without the need to bear the initial financial burden. Projects undertaken on this basis ensures access to lower power cost for the private sector.

The following table compares the key characteristics of various commercial and industrial solar power project models highlighting differences in investment structure, ownership, financing, profitability, payback period, and associated risks.

Table 5: Various open access models

Particulars	Captive/ Group Captive	Third Party	Utility Scale
Investment	100% upfront by consumer (70% loan and 30% equity)	100% by Developer	100% by Developer
Ownership	With Consumer	With Developer	With Developer
Financing	Mostly private funding	Mostly private funding	Mix of Public and Private funding
Profitability	Higher	Higher	Medium
Payback period for developer	Shorter	Shorter	Slightly longer
Offtaker Risks	Lower	Lower	Higher
Operational Risk	Consumer	Developer	Developer

The Indian C&I solar sector added ~10+ GW from Fiscals 2019 to 2023, with the total installed capacity as of March 2023 at ~17 GW. Capacity additions picked up in the last two years in response to the easing of pandemic restrictions and increasing power demand. Further, the market has gained momentum over the last few years, with consumers keen on reducing their power bills, as well as carbon emissions. Increasingly, there is also very strong interest among investors with leading independent power producers, private equity funds, and other institutional investors committing huge sums to this market.

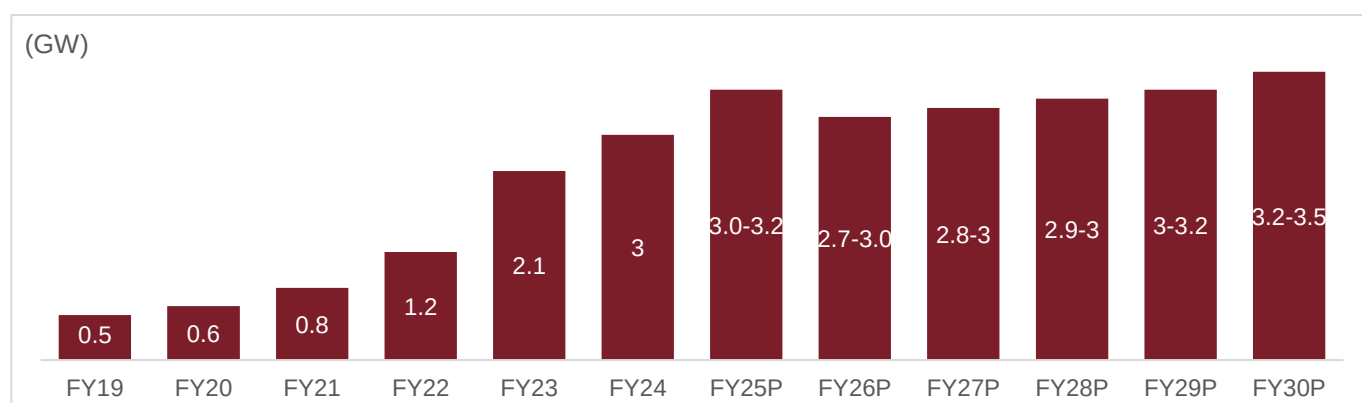
Solar power is preferred over other renewable energy sources by C&I consumers due to its ease of implementation, versatility, and negligible operating costs. Moreover, solar power prices have declined significantly over the past few

years, making it more affordable for C&I consumers. In contrast, state discoms continue to charge C&I consumers very high tariffs compared to residential and public sector consumers to provide subsidies to agricultural and below-poverty-line consumers. Thus, large industries across segments and commercial consumers, including metro corporations, railways, airports, hotels, and multinational corporations, can generate substantial savings by meeting their electricity requirements through solar power-based captive, group captive, and open access projects.

Crisil Intelligence expects 18-19 GW of projects to be commissioned under the open access utility segment over the next five years until 2030, led by the go-green initiatives/sustainability targets of C&I consumers, effective long-term policies in key states such as Uttar Pradesh and Maharashtra, and lower offtake risk.

Additionally, in the proposed Draft Electricity Amendment Act 2022, several progressive measures have been proposed for the solar sector, including the introduction of a pan-India RPO with a strict penalty mechanism. Discoms and other large electricity customers are obligated to purchase a specific percentage of their power from solar energy sources under these RPOs. These measures will provide a significant boost to the uptake of rooftop solar in the C&I segment.

Figure 24: Open access utility scale capacity additions (FY25-FY30)



Note: Historical installed capacity is based on internal estimates. P: Projected

Source: Industry; Crisil Intelligence

3.10 Policy support in terms of incentives for C&I capacity addition

C&I capacity addition is largely influenced by the policy and regulatory framework governing open access. Some of the policies have helped in the C&I segment's growth, whereas certain provisions have acted as obstacles to capacity addition. State-wise variations, coupled with different interpretations of provisions, have constituted a major challenge. To avoid ambiguities, the MoP has issued a few rules to provide greater clarity in various OA-related provisions.

a. Electricity (Promoting Renewable Energy Through Green Energy Open Access) Rules, 2022

- Multiple avenues (own generation, captive, open access, and from distribution licensee) provided to generate, purchase, and consume renewable energy
- Consumers having contracted demand or sanctioned load of 100 kW and above eligible to take power through green energy open access
- No limit on supply of power for captive consumers taking power under green energy open access
- A central nodal agency to set up and operate a single-window green energy open access system for renewable energy
- After registration at a centralised registry, all applications are routed to the concerned nodal agency for the grant of green energy open access

- Monthly banking allowed at least 30% of the total monthly consumption of electricity from the distribution licensee by consumers
- CSS on a C&I consumer shall not be increased, during 12 years from the date of operating of the generating plant using RE sources, by more than 50% of the surcharge fixed for the year in which open access is granted
- Obligated entities can meet their RPO targets by purchasing green hydrogen or green ammonia
- Cross-subsidy surcharge and additional surcharge shall not be applicable if green energy is utilised for the production of green hydrogen and green ammonia

b. Waiver in ISTS transmission charges

The MoP, in August 2020, waived the inter-state transmission system (ISTS) charges and losses on all solar and wind projects commissioned before June 30, 2023. In June 2021, the waiver was extended up to June 30, 2025. However, this time, only the ISTS charges were waived, and losses remained applicable. Subsequently, in November 2022, the waivers were amended giving clarity on period of availability of incentive and a minimum 51% energy from wind/solar for pumped storage and BESS.

Waivers are available for projects commissioned by June 30, 2025. However, post June 2025, an annual increase of 25% in the ISTS charges will be applicable for solar, wind, hydro PSP, and BESS sources, resulting in the applicability of 100% of ISTS charges from July 2028.

Subsequently, in February 2023, it was clarified that green hydrogen and green ammonia projects would get a waiver of ISTS charges for 25 years if the projects are commissioned before June 30, 2025.

c. New hydro power projects:

The MoP has decided to extend the waiver of ISTS charges on the transmission of power from new hydro power projects, for which, construction work is awarded and PPAs are signed on or before June 30, 2025.

ISTS charges will be levied (from 25% from July 25 to 100% in July 28) for the transmission of power from hydro power projects where construction work is awarded and PPAs are signed after June 30, 2025.

d. Cross-subsidy and additional surcharge

Captive power projects are exempt from paying CSS, as per Section 42(2) of the Electricity Act 2003. In its judgement dated December 10, 2021, the Supreme Court ruled that captive power consumers are not liable to pay an additional surcharge under Section 42 (4) of the Electricity Act, 2003.

3.11 Broad overview of Green hydrogen demand

In addition to the increasing popularity of solar energy, there is a growing demand for other renewable sources, such as green hydrogen, biomass, heating & cooling and green steam. Companies that traditionally relied on conventional, non-renewable energy sources in their manufacturing operations are now pivoting towards renewable alternatives to mitigate their carbon footprint. This shift involves retrofitting existing infrastructure and adopting technologies that enable the integration of renewable energy sources into their operations. For instance, a manufacturing company may choose to retrofit their boilers to use green steam generated from renewable sources instead of conventional fuels like natural gas or coal.

Hydrogen is known for being a versatile and lightweight fuel which can be generated through electrolysis, a process where electricity is used to split water into hydrogen and oxygen. When renewable energy is consumed during this process, the result is green hydrogen, which helps reduce the environmental impact of energy production. In India, green hydrogen is expected to cut greenhouse gas emissions by 2.8 MT by 2030. After China and the USA, India is the third largest consumer & producer of hydrogen in the world. In 2020, India's hydrogen demand stood at 6 million tonnes (MT) per year. ~48% hydrogen is used in fertilizers to produce ammonia/urea and ~46% in refineries for hydrodesulfurization. India's grey hydrogen market is estimated to be ~ USD 9-10 billion considering production costs

of ~USD 1.5-1.8 per kg. Additionally, India's annual ammonia consumption for fertilizer production is about 15 MTPA, with roughly 15% of this demand (over 2 MTPA) currently met from imports. Driven by captive consumption by refineries, fertilisers and ammonia, the hydrogen demand is expected to reach ~11-12 MTPA by 2030, making it a ~USD 22-25 billion market. Of this, ~4-4.5 MTPA is expected from refineries, and ~6-6.5 MTPA from fertilisers. A very small quantum (~0.5 to 0.75 MTPA) will be from petrochemicals and other industries. Considering that ~8-10% of hydrogen demand from fertilisers and 22-24% of hydrogen demand from refineries can be met through green hydrogen in 2030, ~1.4-1.8 MTPA will be from green hydrogen. Considering a production cost of ~USD 2 to 2.5 per kg, the green hydrogen market is expected to be worth ~USD 3-4 billion in 2030.

3.12 Outlook on solar hybrid/RTC capacity additions in India

Wind Solar Hybrid (WSH) is fast becoming the preferred RE option in India. Although the MNRE has not yet set a generation target, the nascent sector has received strong support from SECI and several state governments. There are two types of WSH projects — pure-play ones and those with storage. There are also projects that may come up under the government's RTC power scheme, which has a mandatory 51:49 blend of RE and thermal energy.

India has introduced RTC generation tenders, including hybrid tenders, to strengthen clean generation by combining solar, wind and storage technologies. The MNRE introduced the National Wind-Solar Hybrid Policy on May 14, 2018. The main objective of the policy is to provide a framework for the promotion of large grid-connected wind-solar PV hybrid systems and efficient utilisation of transmission infrastructure and land. It also aims to reduce the variability in renewable power generation and achieve better grid stability. As of April 30, 2024, hybrid projects of aggregate capacity of 15022.82 MW are under construction in the country. It is expected that India will witness 15-17 GW of WSH capacity in the next five years (Fiscal 2025 to Fiscal 2029), out of which around 6-7 GW will be from wind.

3.13 Key drivers for solar-hybrid hybrid/RTC capacity additions

The WSH segment in India is experiencing rapid growth, driven by several key factors:

- **Potential:** India has around 696 GW (120 m hub height) wind potential and around 750 GW of solar potential. Currently only around 10% of the potential is developed and the remaining 90% of the potential is yet to be exploited. This provides huge opportunities for wind and solar energy development.
- **Geographical advantages:** India's coastline provides high wind speed as well as excellent solar potential. States such as Gujarat, Maharashtra, Karnataka, Tamil Nadu, and Andhra Pradesh have excellent wind as well as solar potential. Such an advantage provides a great opportunity for the supply of hybrid power. Depending on the project requirements, the hybrid projects can be co-located or located in different locations, also making it more flexible even if natural resources are located in different places.
- **Complementary resources:** Wind and solar sources complement each other. Due to their inherent characteristics, they generate power during different times of the day as well as seasons. Therefore, for 24x7 supply, they complement each other effectively. Hence, WSH projects provide more reliable power and can be used for round-the-clock supply (especially with energy storage).
- **Resource optimisation:** Co-located WSH plants can help with resource optimisation. With optimum land utilisation and infrastructure sharing, the wind and solar resources can be optimally utilized, leading to better CUF as well as cost optimisation. With energy storage facilities, the WSH plants help to achieve better grid management and higher penetration of RE into existing power systems.
- **Policy push:** The policy incentives by the Government of India have also helped the WSH segment. A confluence of increased RPO targets, VGF funding, ISTS waiver, PLI, and solar park schemes, has helped both the resources to thrive.

4 Overview on Indian Solar EPC Market

4.1 Introduction

A typical EPC solar project covers design, civil works, equipment purchase and installation, and commissioning. However, with constrained returns, the scope of an EPC solar project has evolved and now includes O&M services also. Most of the EPC players provide integrated and customised solutions as per the client's requirements through a consultative approach. Favourable government initiatives, increased demand for clean and green energy, and rooftop installations by C&I Consumers have provided impetus to solar installations. The EPC services can be classified into various subcategories based on the scale and type of installations, i.e., utility scale and rooftop solar installations.

Large players such as TATA Power Solar Systems Limited (Tata Power Solar), Larsen & Toubro Limited (L&T), Vikram Solar Limited (Vikram Solar) are also offering EPC services along with some of the key players such as Waaree Renewable Technologies Limited (Waaree Renewable Technologies), Sterling & Wilson Renewable Energy Limited (Sterling & Wilson Renewable), Bharat Heavy Electricals Limited (BHEL), Solarworld Energy Solutions Limited (Solarworld Energy Solutions), Prozeal Green Energy Limited (Prozeal Green Energy), Oriana Power Limited (Oriana Power) and Jakson Green Private Limited (Jakson Green). Most of these players are also present in rooftop solar installation's EPC.

The development of solar power projects in India requires a detailed and extensive process, from conceptualization to commissioning and regulatory approvals. The processes can be broadly divided into following stages:

- **Conceptualization:** Identification of a project location, followed by a feasibility study and project proposal preparation.
- **Engineering:** Design and engineering of the solar power plant, including layout, electrical infrastructure, and civil works.
- **Procurement:** Acquisition of equipment, materials, and services.
- **Construction:** Site preparation, installation of equipment, and construction of civil infrastructure.
- **Commissioning:** Pre-commissioning, commissioning, and performance testing to ensure the plant meets performance guarantees.
- **Regulatory Approvals:** Obtaining necessary permits and approvals during the construction and commissioning phase, including Consent to establish, Consent to operate, Fire NOC, Environment Clearance, Forest Clearance, Grid Connectivity Approval, and registration with the State Nodal Agency etc.

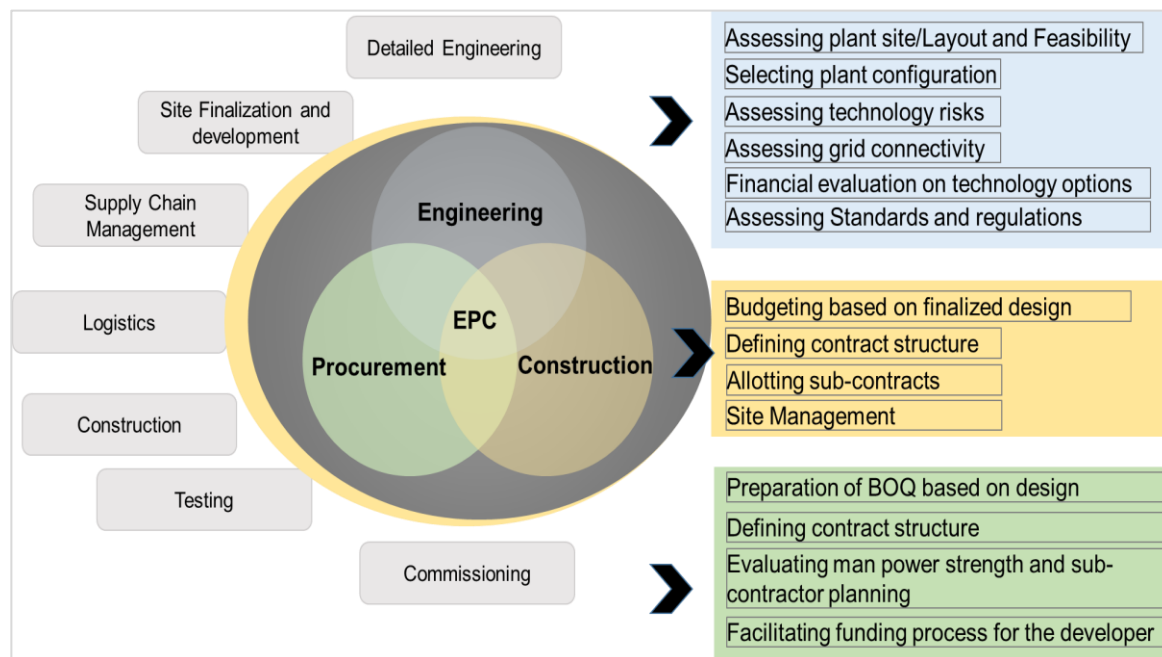
The regulatory framework in India is administered by the Ministry of New and Renewable Energy (MNRE), Central Electricity Regulatory Commission (CERC), and State Nodal Agencies, with key regulations and policies including the Renewable Purchase Obligation, Open Access Policy, Grid Connectivity etc. The entire EPC process typically takes approximately 12-18 months, with an additional 3-6 months for regulatory approvals. However, the process can be challenging, with common obstacles including land acquisition, grid connectivity, off takers, environmental and social impact, and financing.

The overall project works are classified as supply (material) contracts and services contracts and are awarded to different entities instead of one single EPC contractor. The capital-intensive items covering around 75-80% of the project cost, such as modules, transformers, inverters, and cables, are being procured by developers. The developers enter into third-party contracts for services part, covering civil works, commissioning, erection, and mounting of equipment, which forms around 20-25% of the project cost. However, some solar module manufacturers insist on buying the entire package and not just solar modules, since they also provide EPC services.

4.2 EPC project: Turnkey versus balance of plant

Nations, majorly developing ones, have been investing heavily on large infrastructure projects through public as well as private investments. To ensure efficient and timely construction, it is imperative to have an effective model which ensures timely project execution, minimises construction delays and improves transparency. The EPC model is primarily used in the construction and O&M of solar plants.

Figure 25: Checklist of an EPC model



Source: Crisil Intelligence

Under the turnkey project structure, the contractor holds full responsibility for the design and execution of the works, including EPC. Therefore, the contractor makes the facility ready to be used at the turn of a key. The project must be delivered at a pre-determined time and pre-determined cost, and the contractor must adhere to project specifications. In case of deviations, the contractor is liable to pay monetary compensation.

In the case of the balance of plant (BoP) structure, the entire project is broken down into multiple packages with a major chunk contracted through the EPC route and the rest through BoP. For a solar plant, solar modules and inverters constitute the maximum cost and may be contracted singularly whereas the supporting components and systems (wiring, switches, battery banks, power conditioners, mounting structures) may be procured from various manufacturers. Additionally, for the BoP project structure, the owner would have to appoint an external consultant or appoint the principal contractor for holistic project management and act as an interface between subcontractors.

4.3 Project execution using in-house EPC vs outsourcing to specialized EPC players

The Indian solar market has been booming, with capacity additions rising to average ~9000 MW in the past five years (Fiscals 2019-23) from 780 MW in Fiscal 2013. Several projects have been commissioned under the central schemes of NVVN Tranche 1 and JNNSM Phase II and Batch III. Complementary central and state government policies coupled with the increasing price competitiveness of solar power have led to a surge in solar installations. However, declining module prices and aggressive competitive bidding on the part of the players have led to lower solar power tariffs. This has constrained margins for EPC players. To reduce costs, more developers are opting to carry out their own EPC rather than outsourcing to a contractor. Project developers are becoming system integrators, thereby providing holistic turnkey solutions. Standalone, large EPC firms are diversifying their portfolio towards building their

own generation capacities to stay competitive. Smaller EPC firms without the financial prowess for project development are vertically integrating into captive projects and rooftop installations.

Following are some of the key considerations while making decisions.

- Size and complexity of the project
- Budget
- Timelines
- Own level of expertise
- Desired level of control over project

4.3.1 Pros and cons of different business models

Factor	In-house EPC	Outsourcing to large, specialised EPC contractors
Equipment costs	1. Players are likely to get bulk discounts on the prices of solar modules and inverters only if the project size of the developer is large enough (for the equipment supplier, typically >100 MW size). Hence, offering deep discounts is a challenge. 2. Availability of equipment financing is possible only for large capacities and long-term relationship/tie-ups.	1. In the case of turnkey EPC contracts, players with large order books benefit from bulk buying/import of components such as modules and inverters. Hence, they can quote competitive rates, with minimal impact on margins. 2. Most large EPC players get the benefit of equipment financing from the module/inverter supplier.
Project management and timelines	1. Project development and meeting deadlines in the case of in-house EPC projects could be a challenge for relatively new and smaller players in the market. 2. In-house EPC players tend to sublet more of their work to smaller contractors resulting in elongation of project completion deadlines.	Led by varied experience across various geographies, project sizes and teams, project management is smoother. Likelihood of timely project completion is higher owing to better supply chain management.
Warranties, guaranties/ Spare part availability	The developer and O&M contractor bear the entire risk arising due to loss of generation led by multiple technical factors. However, it can be controlled by reducing the replacement time of faulty equipment. The problem is aggravated since major components such as solar modules and inverters are imported, resulting in higher lead time. Hence, in the case of in-house EPC projects, O&M contractors are appointed.	As large EPC contractors also provide warranties and guarantees post commissioning, the lead time for spare parts to be available at the site is less. This reduces generation loss, especially in the peak power generation summer season.
Risk diversification	Although the solar industry is growing, it is still prone to volatility and uncertainty. Solar panels, the major component for a solar plant, are still majorly imported and susceptible to price fluctuations and local taxes (anti-dumping duty, safeguard duty). With capital costs as well as tariffs coming down due to maturing of the market and rise in competitors, solar project margins have also been coming down. In such a scenario, being vertically integrated across development and EPC contracting gives a	EPC players aim to play with scale and cost to improve margins. However, with the top line for the companies falling on a per-project basis (developers not keen to raise EPC and O&M costs), stagnation tends to set in. Most EPC players have already reduced costs by taking strong efficiency measures and more breathing room is unlikely. This leads to risk aggregation and any untoward volatility in the market may distort margins.

Factor	In-house EPC	Outsourcing to large, specialised EPC contractors
	company more scope to diversify risks and secure finance.	
Horizontal expansion	Horizontal expansion is restricted to the tune of business expansion.	In order to grab a larger market share in the business, large and established EPC players foray abroad. With the emergence of international markets in the solar sector such as Africa, Middle East, Southeast Asia, and South America, these players are building upon efficiency and low-cost capabilities to win tenders and augment portfolios.
Firm sustenance and continuity	With solar development coming closer to EPC and concept-to-commissioning being offered in one suite, project developers will build on in-house solutions. However, merger deals for vertical integration are unlikely and companies would prefer investing in building in-house capabilities rather than buying specialised EPC firms.	With the solar sector in India maturing, the sector may see consolidation and merger deals. With pricing pressures and thinning margins, only large and specialised EPC players are likely to remain in business. Bigger players like Sterling & Wilson-Renewable, Mahindra Susten, and Tata Power Solar will continue to have a strong market presence. However, small firms may not be able to sustain due to lower margins.

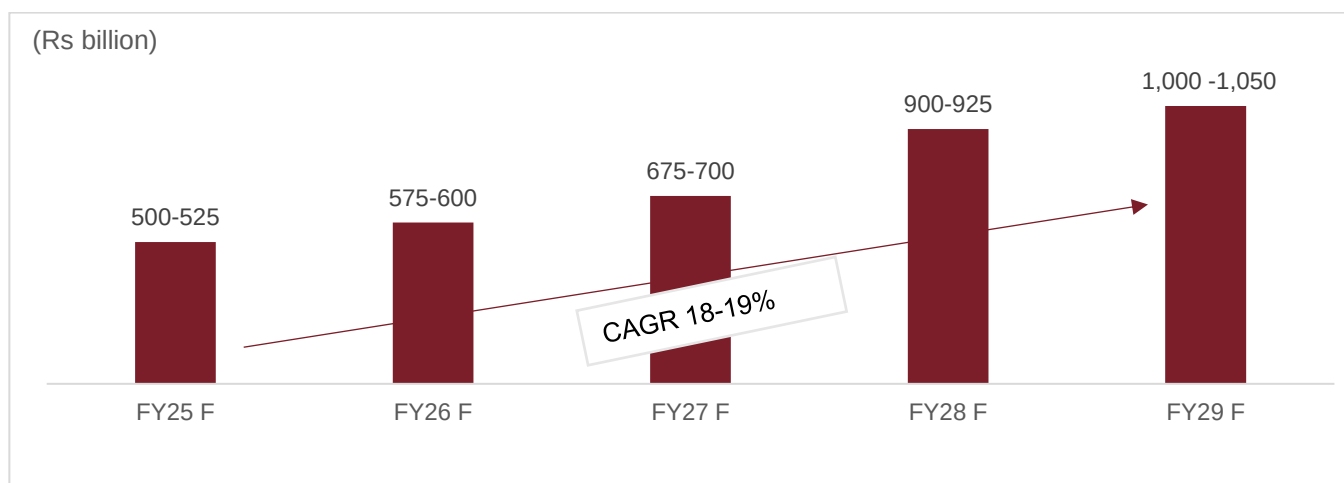
	Cons
	Pros
	Cannot be ascertained

4.4 Outlook on solar EPC Market

Crisil Intelligence foresees a surge in solar power capacity, reaching 137-142 GW from Fiscal years 2025 to 2029, significantly surpassing the 50-55 GW added between Fiscal years 2019 and 2024. Crisi Intelligence expects capacity additions to grow over the next five years, led by strong pipeline build-up under existing and new tendering schemes, improvement in technology, and mixed resource models.

EPC services for Solar energy are dominated by third-party service providers in the country (~40-45%). A solar EPC cost typically ranges from Rs. 45,000 -50,000/kW.

Figure 26: Third Party Solar EPC Market India



F: Forecasted

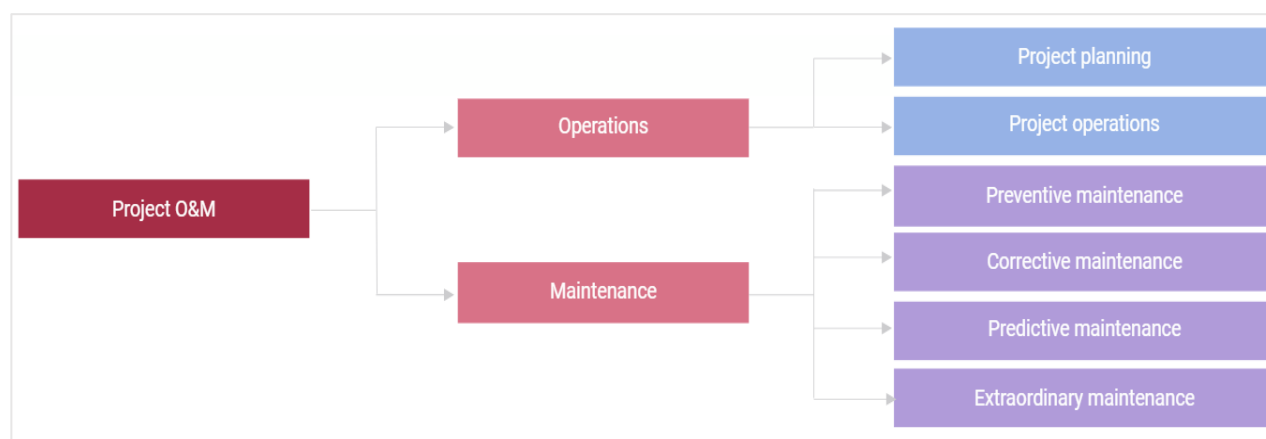
Source: Industry, Crisil Intelligence

Solar O&M Contracts in India

India's solar energy industry has rapidly grown over the previous years as a result of the government's ambitious renewable energy objectives and declining costs associated with PV technologies. The O&M market for solar power is increasingly important in order to maintain the performance and durability of such investments, given the rising numbers of installations.

The O&M market in India for solar power is expanding in tandem with the country's installed capacity which has reached ~ 84 GW as of 31st May 2024. This has spurred demand for comprehensive O&M services to ensure the optimal performance, reliability, and efficiency of the solar plants. Effective O&M practices are essential for maintaining the health of solar installations, minimizing downtime, and maximizing the energy yield.

Figure 27: Solar project O&M



Source: Industry, Crisil Intelligence

- **Planning:** It includes preparing a schedule of maintenance activities, preparing an inventory of spares and tools, and formulating contingency plans in case of equipment breakdown.
- **Project operations:** It includes analysing and reporting plant performance, managing warranty and insurance claims, security, management of spares, overall project supervision and meeting various statutory requirements.
- **Preventive maintenance:** It is based on a pre-determined routine to monitor equipment and prevent faults. It is done at regular intervals agreed upon by both the O&M contractor and the project owner. For example, servicing and cleaning of modules, thermography, and IV curve testing at a scheduled interval.
- **Unscheduled maintenance:** It includes repair of broken-down equipment to a functioning state. O&M contractors must aim to reduce instances of corrective maintenance by ensuring robust scheduled maintenance and preventive maintenance.
- **Corrective maintenance:** It includes fault diagnosis, and repairing a faulty part which takes place after the fault has occurred.
- **Predictive maintenance:** It is a condition-based maintenance carried out by studying and analysing plant performance and degradation patterns of various equipment like modules, inverters, AC/ DC cables, transformers etc. It can help reduce instances of corrective maintenance.
- **Extraordinary maintenance:** These interventions are required for causes beyond the control of the contractor. Non-routine repair arising out of major unpredictable events including theft or fire, endemic failures, modifications required by regulatory changes and equipment design faults.

4.5 Business models for Solar O&M

India's O&M business model is critical to the smooth running and longevity of the projects. The model focuses on the ongoing maintenance and optimal operation of various assets such as power plants, transportation networks, and utility systems. For India, the O&M model is important due to the rapid development of the country's infrastructure and the need to maintain high levels of service delivery. The model includes many key features, including routine inspections, preventive maintenance and repairs, performance monitoring, and predictive analytics. These efforts help provide stable and reliable services to end users by reducing the footprint, lowering operational costs, and extending the useful life of Solar assets.

Table 6: Comparison of self O&M and Third-party O&M

Particulars	Self O&M	Third-party O&M	
		EPC contractors	Independent service providers (ISP)
General overview	- Undertaken by developers with strong technical knowhow and large scale. - Sensitivity about sharing confidential project-level data with third-party vendors. - Many of such developers offer fragmented contracts for vegetation management, security etc.	1-2 years of O&M services bundled with EPC contract. - Accounts for 27-30% of the total market.	- Usually, comprehensive contracts with specialist service providers. - Some developers prefer fragmented contracts for cleaning, security, maintenance etc.
Examples	Adani Green Energy Limited, Azure Power Global Limited, Greenko Energies Private Limited, Acme Solar Holdings Limited, Avaada Energy Private Limited, ReNew Power Limited	Tata Power Solar, Vikram Solar, L&T, Jakson Green, Sterling & Wilson Renewable, Prozeal Green Energy	Mahindra Teqo Private Limited (Mahindra Teqo), Gensol Engineering Limited (Gensol Engineering), Avi Solar Energy Private Limited (Avi Solar Energy), Juwi India Renewable Energies Private Limited (Juwi India Renewable Energies), Param Renewable Energy Private Limited (Param Renewable Energy)
Risk management	All performance liability and cost risk lie with developers	All performance liability and cost risk are outsourced with some guarantees	
Features	- Data confidentiality - Improved product knowledge and direct management control - Unaccounted business overheads - Lack of accountability and penalty enforcement	- Seamless transition from construction to O&M phase - Lower GST rate of 13.8% as part of overall EPC contract in comparison to 18% for standalone O&M contracts	- Finely priced contracts - Clear accountability and penalty provisions for underperformance

Source: Industry, Crisil Intelligence

4.6 Key drivers, threats, and challenges for Indian Solar O&M Market

4.6.1 Key Drivers which affect the Indian Solar O&M market:

- PSUs ramping up renewable project development business
 - With conventional businesses slowing down, PSU developers have set ambitious renewable capacity targets and are bidding aggressively:
 - NTPC: 60 GW by 2032
 - SJVN: 50 GW by 2040
 - NHPC: 50 GW by 2040
 - NLC: 4 GW by 2025
 - Coal India: 3 GW by Fiscal 2030
 - PSU's share in solar capacity addition is expected to increase from 16% in Fiscal 2022 to about 25% by Fiscal 2025.
 - PSU developers outsource all O&M activities. NTPC has already issued solar O&M tenders for more than 900 MW capacity in the last two years.
- Reduction in management effort
 - Leading developers currently have commissioned solar portfolios of 3-4 GW but significantly large capacities in the pipeline.
 - Preference for a third-party model is expected to grow over time to reduce management effort for projects spread across multiple states.
- Sector maturity and growth
 - As the solar sector grows and matures, the third-party O&M model, with clear allocation of risks and responsibilities, is expected to increase.
 - International investors prefer outsourcing O&M and giving complete asset management responsibility to third parties.
 - Average project life for utility scale solar projects in India is currently only 3.5 years. As these plants age and the defect liability period expires, O&M is expected to get increasingly complex, leading to the requirement of specialised O&M contractors.

4.6.2 Threats and challenges which affect the O&M market:

- Execution challenges
 - Sourcing and maintenance of spares for project sites in remote locations is a challenging, time-consuming, and capital-intensive task. Delays in sourcing spares or critical equipment (like inverter/ transformer) can result in extended downtime and disproportionate loss of revenue.
 - The unavailability of water poses a significant challenge at sites located in arid and dry regions like Rajasthan and Gujarat. Use of poor-quality/ untreated water can lead to long-term degradation of modules and reduced generation.
 - Civil disobedience, instances of theft and disruption by locals (lack of jobs, loss of economic opportunities) can cause significant generation losses and result in additional cost implications.
- Lack of skilled manpower
 - Skilled manpower for monitoring plant operations and supervising key activities is not usually available near project locations.
 - Unskilled manpower is available in abundance but needs adequate training in basic engineering tasks and H&S requirements.
- Increasing competitive intensity
 - New players often enter the business attracted by growing market size and low entry barriers. Strong competition results in a low win rate in PSU tenders, dilution on contract terms, and/ or reduction in profit margin.
- Payment delays

- 60–70-day payment delays by developers are fairly common in the industry resulting in high working capital requirements.

4.7 Assessment of Solar O&M Market

O&M services for wind energy are dominated by the equipment manufacturers in the country. A typical wind turbine O&M cost ranges from Rs.1,000-1,500/kW of capacity whereas for solar it ranges from Rs. 200 -300/kW. The type of services offered as a part of O&M contracts include:

Supply of equipment

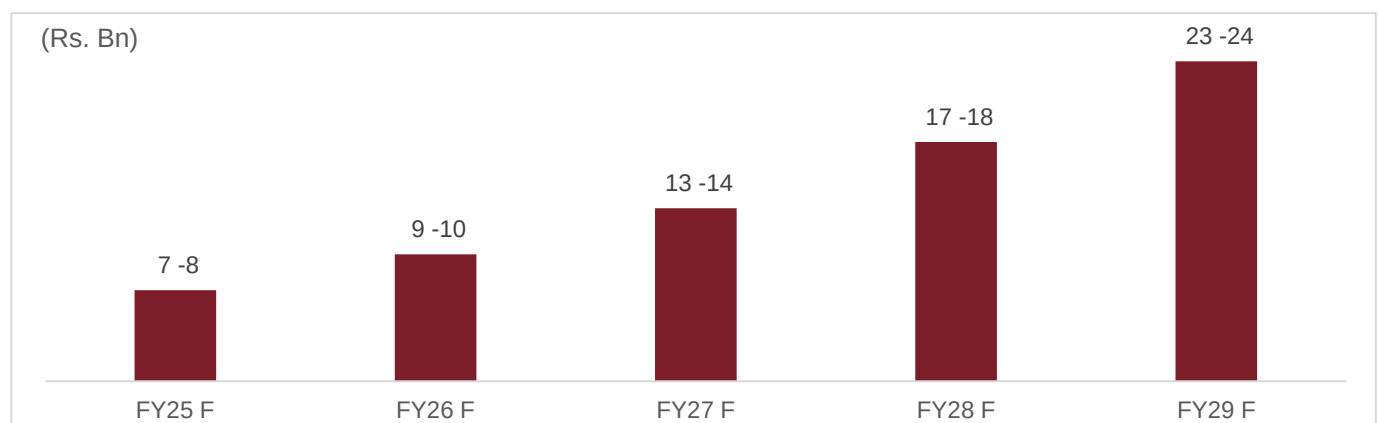
- Large equipment supply
- Sundry or small equipment supply
- Consumables

Repair services

- Regular repair and maintenance
- Major repair or overhaul
- Equipment replacement

Crisil Intelligence foresees a surge in solar power capacity, reaching 137-140 GW from Fiscal years 2025 to 2029, significantly surpassing the 50-55 GW added between Fiscal years 2019 and 2024. This growth is primarily spurred by robust government backing, demonstrated through an aggressive tendering strategy. Crisil Intelligence expects capacity additions to grow over the next five years, led by strong pipeline build-up under existing schemes and new tendering schemes, improvement in technology, and mixed resource models. The third-party O&M services constitute around 30-35% of the total market. Therefore, the demand for third party O&M services is expected to be in the range of Rs. 23-24 billion by Fiscal 2029.

Figure 28: India third party solar O&M services, Fiscal 2024 to 2029



F: Forecast

Source: Industry, Crisil Intelligence

4.8 Key threats and challenges for EPC of solar pumps

Governments of India has been encouraging the use of RE sources, such as solar power, to reduce dependence on fossil fuels and mitigate climate change. PM KUSUM Scheme is specifically developed for increase in penetration of solar pumps. There is a sustained demand for agriculture and irrigation needs and solar pumps is a cost-effective and sustainable solution for irrigation. The government is offering incentives and subsidies to encourage the adoption of solar pumps.

However, there are certain challenges in EPC of solar pumps. The initial capital cost for solar pumps can be more expensive than the conventional pumps. Even with subsidies, farmers may be reluctant to pay upfront costs. Moreover, delays in subsidy disbursement affect the cashflow, making project execution difficult. Water level and sunlight availability also remain concerns, with some farmers dissatisfied with water output during cloudy days. Also, deeper groundwater levels require high HP pumps, which may not be feasible with solar energy alone or require heavy investments in solar panels. The installation of panels requires space which can be a deterrent for farmers, especially if they are losing cultivable land. There is always a fear of solar panels getting stolen specifically in remote areas. Additionally, the availability of spare parts or technicians also discourage farmers from adopting solar pumps.

5 Assessment of EV Charging infrastructure

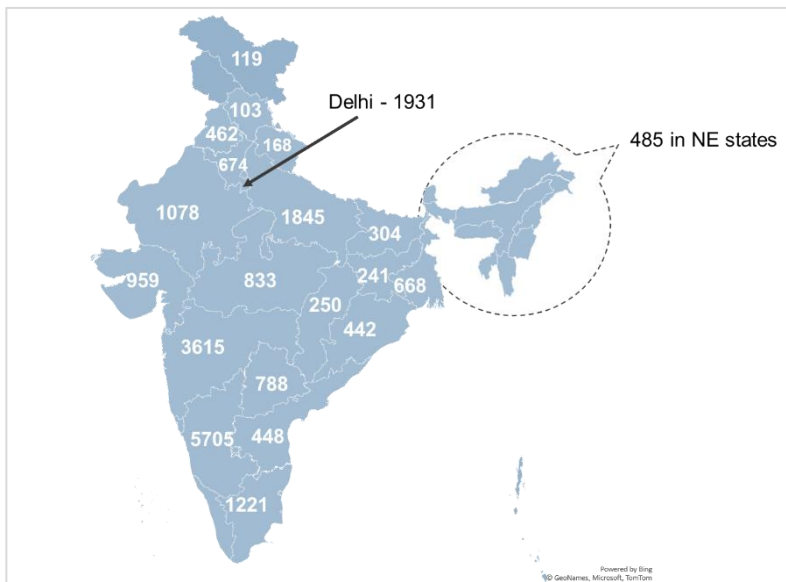
5.1 Existing EV charging infrastructure market

India's electric vehicle (EV) ecosystem has undergone a significant transformation in the last two to three years, with both plug-in charging stations and battery swapping stations (BSS) proliferating at an unprecedented rate. The number of EVs sold in India has also surged from around 160,000 in 2019 to over 2.0 million in 2024, representing a remarkable 9-10 times increase in the absolute number of EVs over the past four years. The growth of the EV segment in India has been notable, with EVs accounting for approximately 7.6% of the total vehicle sales in India in Fiscal 2025 (till December 2024). This surge may be attributed to, amongst others, favorable government policies, rising fuel prices and shifting consumer preferences. Further, the Government of India has targeted EV penetration of 30% by 2030, and NITI Aayog has projected significant growth in EV sales for various vehicle categories. As the Indian automotive industry undergoes a transformative shift towards sustainable mobility, we aim to expand our EV charging station business to meet the growing demand for robust charging infrastructure. The growing demand for public EV charging stations is expected to be driven by various stakeholders including charge point operators, oil marketing companies, utilities, and EV fleet operators.

In 2021, there were only 451 public charging stations (PCS) for EVs, but by December 2024, this number had increased exponentially to over 25,202, as reported by the Bureau of Energy Efficiency (BEE). The actual number of public chargers could be even higher, as many private players have not yet registered their new charging stations on the BEE portal.

States such as Karnataka, Maharashtra, Delhi, UP, and Tamil Nadu are the top 5 states in terms of PCS installation. About 60% of the total PCS are installed in these states.

Figure 29: Public charging stations across different states



Source: Bureau of Energy Efficiency, Crisil Intelligence

India's EV charging infrastructure boasts a wide range of options, encompassing both AC and DC chargers. The AC chargers, including Bharat AC-001, Type-2 AC, and LEV AC, offer a power output spectrum of 3.3 kW to 22 kW, supporting single-phase and three-phase voltage ratings from 230V to 415V. In contrast, DC chargers, such as Bharat DC-001, CHAdeMO, CCS-II, and LEV DC, provide a broader power output range of 12 kW to 500 kW, with voltage ratings spanning 48V to over 1000V. The Indian government's recent approval of LEV charger types has further bolstered the country's EV charging infrastructure. Notably, each charger type is compatible with various

vehicle categories, including electric two-wheelers, three-wheelers, cars, and buses. This underscores India's comprehensive approach to developing its EV ecosystem.

The Bharat AC-001 and Light EV Chargers have become the dominant players in India's public EV charging landscape, with 68% of public charging stations now equipped with at least one of these chargers, up from 59% in December 2023. Designed primarily for smaller vehicles like electric two-wheelers and three-wheelers, these chargers can also accommodate passenger cars and light commercial vehicles. However, their longer charging times make them more suitable for electric two-wheelers and three-wheelers.

Further, the versatility of Type-II AC chargers, capable of delivering power outputs between 7.2 and 22 kW, has led to their growing popularity for charging both three-wheeled and four-wheeled electric vehicles. Meanwhile, in the realm of fast charging, the Combined Charging System (CCS-II) standard has gained widespread acceptance among Indian automakers.

As the electric vehicle market continues to evolve, it is likely to shift towards CCS-II and new LEV DC protocols, with the CHAdeMO standard expected to decline in usage due to its relatively low adoption rates among manufacturers.

Figure 30: Type of chargers in India

Chargers	Bharat AC 001	Type 2 AC	LEV AC	Bharat DC 001	CHAdeMO	CCS-II	LEV DC	LEV DC
Connector types								
Power output	3.3 kW	3/7/11/22 kW	3.3 kW	15/30 kW	25-500 kW	25-500 kW	Upto 12 kW	Upto 12 kW
Rated voltage	230V	230-415 V	230V	48-72 V	500-1000V	500-1000V	120V	120V
Vehicle type								

Source: ARAI, Crisil Intelligence

5.2 Business models for development of EV charging infrastructure

5.2.1 Types of business models

Franchise model - a single entity or a group of companies is granted exclusive rights to operate and maintain a network of EV charging stations across a specific geographic area. The franchise holder is responsible for installing, operating, and maintaining the charging stations, and they typically earn revenue through a combination of subscription fees, usage fees, and advertising. The franchise holder may also have the option to sell charging services to other companies or individuals.

Public private participation: a private company covers the costs of installing, running, and maintaining EV charging stations, while the utility (discom) handles the underlying land and electrical infrastructure. The charging rate is determined through a competitive bidding process, and the private operator assumes the risks associated with investment and revenue. In return, the utility company receives a fixed income stream, regardless of how often the charging station is used. This model can be implemented once EV sales have gained momentum. One potential hurdle is securing affordable land, but this can be addressed by targeting locations with high demand, such as institutions, large residential complexes, and busy urban areas. Alternatively, local authorities can provide land at a lower cost, making the venture more financially viable for utility companies.

5.3 Regulatory framework and incentives for setting up charging infrastructure

To accelerate the growth of EV charging infrastructure, the Indian government has launched the FAME II scheme, which provides subsidies of 50% to 100% for the establishment of 7,580 charging stations across all states based on location. The central government has also introduced several supportive policies, including the removal of licensing requirements for public charging stations, a reduction in GST on chargers from 18% to 5%, and a special electricity tariff that does not exceed more than 20% of the average cost of supply during non-solar hours. Furthermore, the Phased Manufacturing Programme (PMP) for EV chargers aims to increase domestic value addition to at least 50% for various charger sub-systems between December 2021 and December 2024, making it a mandatory requirement for suppliers to government entities. The ultimate goal of this scheme is to promote the localization of the supply of components and foster a robust ecosystem of suppliers.

Figure 31: Favourable policies and regulations to drive EV charging infrastructure

FAME II	Supporting policies and guidelines	State EV policy
- Subsidies for deployment of 7580 charging stations across states - Incentive from 50-100% based on charging station location 50% - At semi-restricted premises for commercial/non-commercial purpose 70% - At public places 100% - At state/central govt offices	- No license required to setup public charging stations - GST reduction from 18% to 5% on chargers - Special electricity tariff not exceeding ACoS+20% during non-solar hours - Atleast 1 charging station per 3x3 km grid in urban areas & every 25 km on highways	- Capital incentives for setting up charging infra & swapping stations - SGST reimbursement - Subsidised electricity tariffs with separate connections - Building planning code updated with certain fraction of parking lots dedicated to EV

Source: Gov Policies, Crisil Intelligence

In addition to central government policies, state governments have also been providing capital incentives, tax breaks, and subsidized electricity tariffs to accelerate the development of charging infrastructure. Due to these transformative policies, India has experienced significant growth in the expansion of its charging infrastructure.

5.4 Growth drivers and challenges for scaling up charging infrastructure

The EV charging infrastructure business in India is expected to witness significant growth opportunities in the coming years, driven by the government's push for electric mobility, increasing adoption of EVs, and declining battery costs. As the cost of EVs decreases, their adoption is expected to increase, leading to a surge in demand for charging infrastructure. The government plans to develop EV charging infrastructure along highway corridors, which will enable long-distance EV travel and increase the adoption of EVs. However, with rising opportunities, there are a few challenges to expand EV charging infrastructure in the country. Some of the challenges are mentioned below:

EV charging Infrastructure financing - Due to the low-capacity utilization of charging stations, cash flows projected are low in comparison to the high investment in the form of capex, energy cost, grid connection cost, land fee etc. Hence, most of the financial institutions are not ready to finance charging projects.

Lack of connector standardization among EV batteries - As of now, Japanese CHAdeMO, European Combined Charging System (CCS) and the Indian Bharat Standard are being used in the industry but if we want to take EVs to every nook and corner of the country, the standardization of EV charging infrastructure is the key.

High investment in infrastructure from the public sector - Transmission lines, power stations, power distribution centres, and metering infrastructure need to be upgraded over time as the demand increases. Power outages, voltage fluctuation, and frequency regulation are some of the other issues that need to be addressed.

Lack of space - Most of the urban cities in India are unplanned and congested. Finding suitable space for setting up charging stations, particularly in metropolitan areas, is a challenge. EVs require time for charging, and the real estate costs are high in most of the urban cities. This creates a dilemma regarding whether to charge parking fees from customers."

6 Heating, Ventilation, and Air Conditioning (HVAC) Market

6.1 Industrial decarbonisation in heating and cooling

With the Government of India's push towards sustainability and various supportive policies, the Indian HVAC market is moving towards the decarbonization of HVACs. Government programs such as the Perform, Achieve and Trade (PAT) scheme and strict green building codes advocate for energy-efficient HVAC solutions. As a result of these rules, both new construction as well as retrofit projects are changing, with a greater focus on advanced HVAC technologies that cut carbon emissions and energy use.

India's HVAC sector is focusing on energy efficiency and technologies such as Variable Refrigerant Flow (VRF) systems and high-efficiency chillers, are becoming popular. Energy Performance Contracting (EPC) models are also helping companies upgrade to energy-efficient HVAC systems without large upfront costs.

With a focus on sustainability and energy efficiency, the use of renewable energy in HVAC is also gaining traction. Solar-powered HVAC systems and hybrid solutions that mix traditional HVAC with renewable energy and energy storage are becoming popular. This change helps in reducing carbon emissions and meeting sustainability goals.

Smart HVAC solutions are on the rise by using Internet of Things (IoT) technology and smart controls. These advanced technologies allow real-time monitoring and optimization, improving energy efficiency. AI-driven predictive maintenance is also making systems more reliable and cutting operational costs.

Corporate houses are setting high sustainability and environmental related goals due to increased awareness and corporate responsibility towards sustainable operations. Many of the corporates are including decarbonized HVAC solutions in their Environmental, Social, and Governance (ESG) strategies and seeking green certifications, such as LEED and GRIHA, which promote energy-efficient systems.

Increased urbanisation and industrialization are driving India's HVAC market, and it is growing rapidly. This growth has led to more investments in R&D for new decarbonized HVAC technologies and has created new opportunities in the market.

Collaborations and partnerships are increasing in the industry. Technology providers, energy consultants, and building developers are working together to promote the decarbonization of HVACs. Indian companies are also partnering with international firms to use global expertise and advanced technologies to speed up the move towards sustainable HVAC solutions.

6.2 Growth drivers

a) Rising demand for energy-efficient and sustainable cooling solutions

The demand for decarbonization in HVAC systems in India is increasing due to growing environmental concerns and government initiatives such as the Energy Conservation Building Code (ECBC) aimed at reducing carbon emissions. As a result, there is a shift towards energy-efficient and sustainable HVAC solutions, with a focus on commercial and industrial buildings. Moreover, advancements in heat pumps, smart controls, and renewable energy integration are bolstering the attractiveness of these systems, promising notable energy savings and operational efficiencies compared to traditional models. Companies such as Danfoss and Mahindra Group are launching initiatives to promote decarbonization and provide resources for organizations to achieve net zero buildings. These efforts not only align with India's international climate commitments but also drive innovation and investment in clean energy, solidifying decarbonisation of HVAC as a crucial aspect of sustainable building practices in the country.

b) Rising government support for green initiatives

India's decarbonisation of HVAC systems is growing rapidly due to strong government support for green initiatives. The government promotes energy efficiency and sustainability through policies like ECBC and financial incentives

like subsidies and tax rebates. Many leading companies in India are voluntarily disclosing their carbon emissions and taking steps to reduce them, such as switching to energy-efficient technologies, using renewable energy sources, and buying carbon offsets. Strict environmental regulations and emission targets also drive industries to adopt decarbonisation of HVAC solutions. The government is funding research and development in green HVAC technologies and has outlined a roadmap for sustainable growth, emphasizing energy efficiency and environmental sustainability. The Union Budget 2023-24 outlined a roadmap for sustainable growth, emphasizing it as one of the pivotal pillars for achieving India@100 under Amrit Kaal. Initiatives encompassed diverse sectors including green fuel, energy, mobility, agriculture, infrastructure, and buildings. Public awareness campaigns and international commitments further reinforce India's commitment towards reducing carbon emissions and promoting a sustainable future.

c) Advancements in HVAC technology

Smart HVAC solutions are on the rise by using Internet of Things (IoT) technology and smart controls. These systems allow real-time monitoring and optimization, improving energy efficiency. AI-driven predictive maintenance is also making systems more reliable and cutting operational costs.

6.3 Overall market size for HVAC

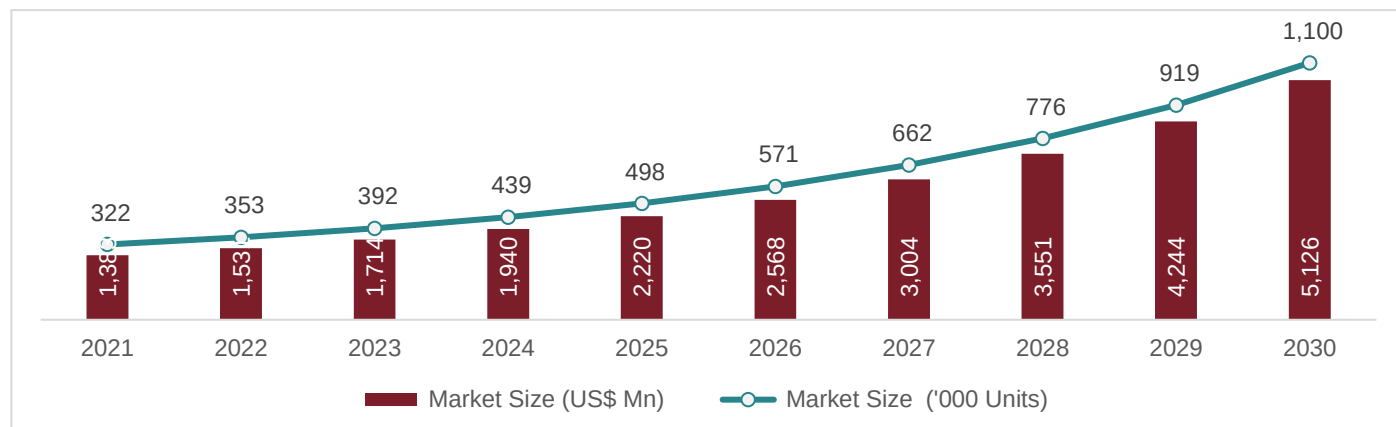
Several key factors drive the decarbonization of HVAC systems in India's industrial and commercial sectors. Government policies, such as the Perform, Achieve and Trade (PAT) scheme, along with incentives, subsidies, and tax rebates, promote energy-efficient technologies. Technological advancements, such as the adoption of VRF systems and the use of renewable energy sources such as solar power, also speed up this shift.

Economic factors are important, as the initial cost of upgrading to decarbonized HVACs can be high. However, the potential for long-term energy savings and lower maintenance costs makes these investments attractive. For instance, India allocates approximately 20-22% of its GDP to public procurement, representing a significant lever for driving decarbonization efforts in sectors such as steel and cement. In 2021, India partnered with the UK and UNIDO to launch the Industrial Deep Decarbonization Initiative (IDDI). This collaborative effort aimed to unite various stakeholders in establishing markets for low-carbon industrial materials. Additionally, market demand and competitive pressure push companies to adopt sustainable practices, driven by client expectations and the pursuit of green building certifications such as LEED and GRIHA.

Corporate responsibility and Environmental, Social, and Governance (ESG) goals also encourage the adoption of decarbonized HVACs. Companies want to improve their public image and meet their sustainability targets. Operational needs, such as efficiently handling high heating and cooling loads, require advanced HVAC solutions that can be customized and scaled to specific needs.

Technological and financial support, including investments in research and development for new HVAC technologies and the use of Energy Performance Contracting (EPC) models to finance upgrades based on energy savings, help this transition. Social and environmental awareness among employees and stakeholders also drives the move towards more sustainable HVAC solutions, while changing environmental regulations continue to shape industry practices.

Figure 32: HVAC Market in India (UDS Mn) is expected to grow at CAGR of 18.2% over FY 25 to FY30



Source: Global Market Insights Research, Crisil Intelligence

7 Overview of key players

7.1 Competitive mapping of Solar O&M players in India

The O&M in the solar industry is evolving rapidly, with numerous companies optimizing their services to meet the increasing demand. Below are the Key players in the O&M market that are majorly acting as a third-party O&M.

Table 7: Key players for Solar O&M

Parameters	Mahindra Teqo	Sterling and Wilson Renewable	Param Renewable Energy	PowerSun India	Jakson Green
Business scale and price competitiveness	- One of the prominent and leading O&M contractors with a GW-scale portfolio, - Aggressive in winning new business	- GW-scale portfolio - Low competitiveness due to high losses in recent times	GW-scale portfolio	GW-scale portfolio	GW-scale portfolio
Business development capability and risk appetite	- Strong business development capability with pan India presence - Balanced risk tolerance	- Only player with global scale of operations - Conservative Investments	Focusses on smaller projects <20 MW.	Conservative Investments	- Conservative Investments - Pan India presence
Access to working capital	Strong	Strong	Weak	Weak	Strong

Parameters	Mahindra Teqo	Sterling and Wilson Renewable	Param Renewable Energy	PowerSun India	Jakson Green
Execution capability	Strong execution track record across multiple technologies and projects	Background in diverse technologies such as energy storage, floating solar, bioenergy and waste-to-energy	Limited technology portfolio	Limited technology portfolio	Background in diverse technologies such as Solar, Hydrogen, Electrolyser, BESS
Range of services	- Comprehensive O&M - Value added services like AI-based predictive maintenance, module performance analytics, thermography	- Comprehensive O&M - Value added services like data analytics, thermography, and underground cable fault finder	- Comprehensive O&M - Fragmented services including manpower for vegetation management, security, module cleaning etc.	- Comprehensive O&M - Value added services like remote monitoring and analysis, asset management	- Comprehensive O&M - Value added services such as Electrolyser manufacturing, remote monitoring and analysis, asset management
Experience (Years)	8	7	5	10	~ 14

Source: Industry, Company websites, Crisil Intelligence

7.2 Competitive landscape of EV charging infrastructure players

The competitive landscape of EV charging infrastructure in India is rapidly evolving, with multiple players vying for market share. Established companies like Tata Power EV Charging Solutions Limited (Tata Power EV), ABB India Limited (ABB), Servotech Renewable Power System Limited (Servotech Renewable) are leveraging their existing infrastructure and expertise to expand into the EV charging space. Meanwhile, CPO startups like Tecso ChargeZone Private Limited (ChargeZone), Sharify Services Private Limited (Sharify Services), Charzera Tech Private Limited (Charzera Tech) are disrupting the market with innovative business models and technologies. Additionally, oil and gas majors like Indian Oil Corporation Limited, Bharat Petroleum Corporation Limited, and Hindustan Petroleum Corporation Limited are also investing heavily in EV charging infrastructure to future-proof their businesses. Furthermore, the Indian government's push for electrification of transportation has attracted international players like Shell Plc, Adani Total Energies E-mobility Ltd, and Enel X Services India Pvt. Ltd., which are partnering with local companies to set up charging networks. With the market expected to grow exponentially in the coming years, the competitive

landscape is likely to become even more aggressive, with new entrants and partnerships emerging to meet the increasing demand for EV charging infrastructure. A comparison of the offerings of some of the key OEMs and CPOs is listed below.

Table 8: Competitive assessment of key players in EV charging space

Parameters	Prozeal Green Energy	Tata Power EV	ABB	Sharify Services	ChargeZone	Charzera Tech	Servotech Renewable
Business	EPC & CPO	CPO	OEM	CPO	CPO	CPO	OEM
Brand name	PROCharge	EZCharge	Terra	Statiq	-	-	Incharz
Total no. of charging stations	29+ charging stations	4,932+ charge points 442+ e-bus charge points 61,959+ home chargers 450+ charge points on all major national and state highways	0.68 million EV chargers with 30,000 DC fast chargers and 0.65 million AC chargers	1,200+ charging stations with 7000+ charge points	850+ charging stations with 2700+ charge points	335 charging stations	2,400+ EV chargers
Charger technology	60/120/360 kW CCS 2 charger 7/22 kW Type 2 AC charger	50/60 kW DC Fast charging AC charger E-bus charger 30kW DC/Fleet charger	3-22 kW AC charger 50-180 kW DC fast charger 11-24 kW DC charger Depot charger for fleet charging	60 kW DC Dual gun charger with CCS-2 connector 22 kW AC charger with type 2 connector 3.3 kW AC home charging	7.7 kW Type 2 DC Fast charger 7.7 kW Type 2 AC charger	60 kW DC CCS type charger 7.5 kW Type 2 charger	3.3/11 kW AC charger 7.2 kW Type-2 charger 10 kW Bharat AC 001 14/22 kW Hybrid AC charger 15/20/30 kW CCS-2 single gun 60/120/180/360 kW CCS-2 dual gun
Geographical presence	NA	450+ cities in India	85+ countries	63+ cities in India	25+ cities in India	160+ cities in India	NA
Collaborations/ tie-ups	NA	Tata Motors, Jaguar, Land Rover, MG, TVS, Volvo, Hyundai	Acquired controlling stake in Indian firm Numocity	Tata Motors, Mahindra, Adani, GMR	Tata Motors, Switch, MG, Eicher, Log9, BYD, Ather, Audi, Mercedes	Hero Electric	Adani Total Energies, IOCL, HPCL, BPCL

Source: Company websites, Industry reports, Crisil Intelligence

Table 9: Key players in HVAC

Particulars	Carrier	Daikin	LG	Blue Star	Whirlpool	Voltas	Samsung
Global Headquarters	Connecticut, U. S	Osaka, Japan	Seoul, South Korea	Mumbai, India	Gurugram, India	Mumbai, India	South Korea
Year of Establishment of parent company	1915	2000	1947	1943	1960	1954	1969
Product/Service-related to HVAC	• AquaEdge® 19DV Water-Cooled Centrifugal Chiller • AquaForce® 30XV Air-Cooled Variable Speed Screw Chiller • AquaForce® 30XW Water-Cooled Screw Chiller • WeatherExpert® Rooftop Units • Infinity® 26 Air Conditioner • Infinity® 24 Heat Pump • CO2OLtec® Evo Transcritical CO2 Refrigeration System • BluEdge™ Service Platform • AdvanTE3C™ Solutions Center	• Energy-Efficient Air Conditioners and Heat Pumps • Refrigerants with Lower Global Warming Potential (GWP) • Smart HVAC Systems • VRV (Variable Refrigerant Volume) Systems • Energy Recovery Ventilation Systems • Chillers and Air Handling Units	• Air Conditioning Systems • Heat Pumps • Chillers • Smart HVAC Controls	• Air Conditioning Systems • Chillers • Heat Pumps • Smart Controls and Building Management Systems	• Energy-Efficient Air Conditioners • Heat Pump Technology • Smart HVAC Systems • Environmentally friendly refrigerants • HVAC Systems with Renewable Energy Integration • Advanced Filtration Systems	• Inverted Air Conditioners • Ducted AC Systems • Chillers • Heat Pumps	• Digital Inverter Technology HVAC • Heat Pump Technology HVAC

Source: Industry, Company websites, Crisil Intelligence

7.3 Competitive mapping of solar EPC players

The solar EPC market is highly competitive, and competitors include global and regional solar EPC and O&M service providers. The solar EPC sector is also highly fragmented but has been trending towards increased consolidation in recent years.

In terms of operating revenue, Tata Power Solar Systems Ltd. and Sterling and Wilson Renewable Energy Ltd. surpass Rs.30 billion. Prozeal Green Energy Limited, Gensol Engineering Limited, Rays Power Infra Limited, Waaree Renewable Technologies Limited and KPI Green Energy Limited have revenues over Rs. 7.5 billion.

Competitive mapping covers the details of companies, their products and services within a given market to understand competitive intensity. Some of the key players having substantial installed EPC capacity include Prozeal Green Energy (700+ MW), Gensol Engineering (770+ MW), Rays Power Infra (1,207 MW), Sterling & Wilson Renewable (18,000 MW), Tata Power Solar (11,500 MW).

Table 10: Key Operational and Financial parameters of leading project developers

Particulars (Rs. Mn, unless noted otherwise)	Prozeal Green Energy Ltd.				Gensol Engineering Ltd.				KPI Green Energy Ltd.			
	H1 FY2025 (A)	FY2024 (A)	FY2023 (A)	FY2022 (A)	H1 FY2025 (UA)	FY2024 (A)	FY2023 (A)	FY 2022 (A)	H1 FY2025 (UA)	FY2024 (A)	FY2023 (A)	FY 2022 (A)
Operational Metrics												
Order Book (Value)	22,209.22	5,994.40	3,461.32	2,543.41	34,000.00	14,480.00	13,300.00	4,030.00	NA	NA	NA	NA
Order Book (MWp)	929.08	253.85	106.78	83.30	NA	NA	NA	NA	2409+	1230+	116+	83+
Total number of constructed solar power projects in the period/year	8	31	20	17	NA	NA	400+	NA	NA	NA	NA	NA
Total number of contracted solar power projects in the period/year	40	46	17	27	NA	NA	NA	NA		NA	NA	NA
Constructed capacity (MWp) during the period/year	62.30	422.61	77.80	66.47	NA	180	240	NA	88	132+	175+	107
Contracted capacity (MWp)	737.53	569.68	101.28	111.34	NA	NA	NA	NA	NA	868+	74+	NA
Contract value of new EPC contracts for solar power projects entered into during the period/year	20,674.01	11,364.95	4,294.44	3,366.73	NA	NA	NA	NA	NA	NA	NA	NA
Capacity of O&M Projects (MWp)	361.74	327.11	185.30	132.29	NA	NA	NA	NA	NA	523.1	NA	NA
Total number of O&M projects	57	55	34	26	NA	NA	NA	NA	NA	NA	NA	NA
Financial Metrics												
Revenue from operations	4,685.40	9,488.82	3,409.96	2,871.85	7,085.10	12,110.80	3,979.70	1,604.10	7,076.89	10,239.00	6,437.86	2,299.41
Growth in revenue from operations	NC	178.27%	18.74%	NC	NC	204.31%	148.10%	NC	NC	59.04%	179.98%	NC
EBITDA	687.13	1,247.35	324.91	115.44	2,037.30	2,231.70	768.20	190.40	2,657.85	3,368.43	2,084.91	1,088.92
Growth in EBITDA	NC	283.91%	181.45%	NC	NC	190.51%	303.47%	NC	NC	61.56%	91.46%	NC

Particulars (Rs. Mn, unless noted otherwise)	Prozeal Green Energy Ltd.				Gensol Engineering Ltd.				KPI Green Energy Ltd.			
	H1 FY2025 (A)	FY2024 (A)	FY2023 (A)	FY2022 (A)	H1 FY2025 (UA)	FY2024 (A)	FY2023 (A)	FY 2022 (A)	H1 FY2025 (UA)	FY2024 (A)	FY2023 (A)	FY 2022 (A)
EBITDA Margin	14.67%	13.15%	9.53%	4.02%	28.75%	18.43%	19.30%	11.87%	37.56%	32.90%	32.38%	47.36%
Profit for the year (PAT)	515.95	922.44	215.21	100.71	496.20	782.20	233.30	111.20	1,359.45	1,616.57	1,096.28	432.45
PAT Margin	10.85%	9.67%	6.30%	3.47%	6.99%	6.44%	5.79%	6.85%	19.11%	15.68%	16.94%	18.68%
Return on Equity (ROE) %	23.67%	69.87%	46.53%	65.15%	10.12%	26.66%	18.34%	26.85%	9.71%	29.56%	53.26%	32.51%
Return on Capital Employed (ROCE) %	22.77%	60.72%	39.56%	60.98%	10.90%	17.34%	9.27%	8.32%	12.58%	24.24%	29.28%	22.56%
Net Debt to Equity Ratio	0.09	0.08	0.45	(0.19)	1.59	2.69	1.14	1.53	(0.09)	0.79	1.82	2.02
Net Working Capital (in value)	2,493.85	1,785.44	932.43	146.90	5,075.10	4,885.30	893.90	1,008.31	8,533.76	6,835.89	1,341.53	1,010.63
Net Working Capital Days	97	69	100	19	131	148	82	229	221	244	76	160

Particulars (Rs. Mn, unless noted otherwise)	Sterling and Wilson Renewable Energy Ltd.				Waaree Renewable Technologies Ltd.			
	H1 FY2025 (UA)	FY2024 (A)	FY2023 (A)	FY 2022 (A)	H1 FY2025 (UA)	FY2024 (A)	FY2023 (A)	FY 2022 (A)
Operational Metrics								
Order Book (Value)	105,490.00	80,840.00	49,130.00	32,530.00	NA	NA	NA	NA
Order Book (MWp)	28,700.00	30,000.00	22,900.00	NA	1,700	2,365.00	817.00	NA
Total number of constructed solar power projects in the period/year	NA	NA	NA	NA	NA	NA	NA	NA
Total number of contracted solar power projects in the period/year	NA	NA	NA	NA	NA	NA	NA	NA
Constructed capacity (MWp) during the period/year	NA	NA	NA	1,150	NA	704	295+	25.4
Contracted capacity (MWp)	NA	NA	NA	NA	NA	NA	NA	NA
Contract value of new EPC contracts for solar power projects entered into during the period/year	NA	NA	NA	NA	NA	NA	NA	NA
Capacity of O&M projects (MWp)	7,800.00	7,670.00	7,000.00	6,600.00	NA	500+	480+	NA
Total number of O&M projects	NA	NA	NA	NA	NA	NA	NA	NA
Financial Metrics								
Revenue from operations	19,455.50	30,353.70	20,150.10	51,989.40	7,608.21	8,765.03	3,509.59	1,614.96
Growth in revenue from operations	NC	50.64%	(61.24)%	NC	NC	149.74%	117.32%	NC
EBITDA	428.30	(225.70)	(11,299.90)	(9,134.80)	1,126.45	2,071.81	837.45	235.06
Growth in EBITDA	NC	(98.00)%	23.70%	NC	NC	147.39%	256.27%	NC

Particulars (Rs. Mn, unless noted otherwise)	Sterling and Wilson Renewable Energy Ltd.				Waaree Renewable Technologies Ltd.			
	H1 FY2025 (UA)	FY2024 (A)	FY2023 (A)	FY 2022 (A)	H1 FY2025 (UA)	FY2024 (A)	FY2023 (A)	FY 2022 (A)
EBITDA Margin	2.20%	(0.74)%	(56.08)%	(17.57)%	14.81%	23.64%	23.86%	14.56%
Profit/(loss) for the year (PAT)	134.00	(2,107.90)	(11,749.60)	(9,157.60)	816.78	1,452.19	553.33	88.91
PAT Margin	0.67%	(6.75)%	(55.27)%	(17.30)%	10.65%	16.49%	15.70%	5.24%
Return on Equity (ROE) %	1.41%	(58.99)%	(353.09)%	(117.13)%	28.94%	87.66%	96.35%	21.15%
Return on Capital Employed (ROCE) %	2.15%	(2.45)%	(73.48)%	(75.24)%	34.37%	98.24%	82.58%	16.32%
Net Debt to Equity Ratio	0.44	0.14	(7.99)	(0.08)	(0.50)	(0.33)	0.26	(0.01)
Net Working Capital (in value)	12,511.40	9,742.90	14,966.80	6,805.20	211.62	233.26	(319.36)	(307.49)
Net Working Capital Days	118	117	271	48	5	10	NM	NM

Note:

1. Based on publicly available information; H1FY2025 (1 April 2024 – 30 September 2024); UA: Unaudited; A: Audited
2. Gensol Engineering Ltd adopted IND AS from FY2024 onwards, and hence the financial metrics for the period ended September 30, 2024, March 31, 2024 and March 31, 2023 (prior period numbers) are stated as per IND AS. However, to maintain consistency in the P&L and Balance Sheet numbers for year ended March 31, 2022, the metrics for FY2022 are as per Indian GAAP.
3. For Prozeal Green Energy, constructed capacity refers to the project capacity for which 80.00% of the total contract value has been recognised as revenue.
4. Financial metrics for the period ended September 30, 2024 have not been annualized.

Source: Company websites, SEBI filings, annual reports, Crisil Intelligence.

Formulae used:

EBITDA: Profit before tax + Finance cost + Depreciation and amortization expense - Other income

EBITDA Margin: EBITDA / Revenue from operations

PAT: Profit for the year (profit after tax)

PAT margin: PAT / Total income

Return on equity: PAT/Average total shareholders' equity

Return on capital employed: EBIT/ Average capital employed, where EBIT is EBITDA - depreciation and amortisation and capital employed is total shareholders' equity + non-current borrowings + current borrowings. Average capital employed is calculated as the capital employed as at the beginning of the period/year plus the capital employed as at end of the period/year, divided by two.

Net-Debt-to-Equity ratio: (non-current borrowings + current borrowings – cash and cash equivalents – bank balances other than cash and cash equivalents)/ total shareholders' equity at the end of the period/year

Net Working Capital: (current assets-cash and cash equivalents incl. other bank balances)-(current liabilities-current borrowings-lease liabilities)

Net Working Capital Days: Net Working Capital/revenue from operations*No. of days during the period/year

- Prozeal Green Energy is focused on delivering end-to-end renewable energy solutions, including engineering, procurement and construction (“EPC”) of solar energy projects on a turnkey basis, with an emphasis on serving clients in the commercial and industrial sectors.
- Prozeal Green Energy is one of the pioneer players to provide “Plug and Play” set up for solar power projects with a portfolio of solar parks across various states in India. It provides a pre-developed, ready-to-use infrastructure where it installs solar infrastructure and connects to the grid, allowing clients to avoid the complexities of starting from scratch.
- Since Prozeal Green Energy’s inception in 2013 to September 30, 2024, the company successfully executed 182 solar power projects with a total installed capacity of 783.98 MWp across 17 states in India and Nepal.
- Prozeal Green Energy constructed 422.61 MWp of solar power plants in Fiscal 2024, which accounted for ~3.53% of total utility scale solar power capacity added in Fiscal 2024 in India.
- Prozeal Green Energy had a Net Debt-to-Equity ratio of 0.09 and 0.08 as at September 30, 2024 and March 31, 2024, respectively, indicating a low level of leverage of the company.
- From the above peers, Prozeal Green Energy:
 - had the highest percentage increase in EBITDA from Fiscal 2023 to Fiscal 2024 of 283.91%;
 - had the second highest Return on Equity for Fiscal 2024 of 69.87%;
 - had the second highest Return on Capital Employed for Fiscal 2024 of 60.72%;
 - had the second highest growth in revenue from operations from Fiscal 2023 to Fiscal 2024 of 178.27%;
 - had the second lowest Net Working Capital Days for Fiscal 2024 of 69;
 - had the third highest profit for the year for Fiscal 2024 of Rs. 922.44 million; and
 - is the fourth largest solar EPC company in India in terms of revenue from operations in Fiscal 2024

8 Key challenges/threats

8.1 Key challenges and threats impacting renewable energy sector

8.1.1 Threats

Any adverse shift in government policies, including reductions in incentives or changes in energy regulations, can significantly impact Prozeal Green Energy's revenue and profitability. However, considering the COP commitment, climate change ambitions and government push for RE, the chances of drastic changes in regulatory regime are less likely. This can also be ascertained from the fact that as against capacity addition of ~70 GW of RE, only ~20 GW of conventional capacity has been added over the last 5 years (FY2019-FY2024). There were some delays in signing PSAs having higher tariffs by Discoms due to declining tariffs in subsequent tenders. However, with the government's plan for stricter adherence to RPOs, higher penalty in case of non-compliance, and revision of tariff in manufacturing-linked tenders, PSA signing activity improved during Fiscal 2022 onwards. There are only a few states which are complying with the RPO obligations fully and there has been limited enforcement on obligated entities - discoms and open access and captive power users - to meet RPO targets. The proposed amendment to the Electricity Act 2003 has stipulated a penalty on RPO non-compliance and uniform imposition of penalties and strict enforcement would be critical for significant improvement and fair distribution of RPO compliance across states. The solar power industry is currently facing cost pressures on account of volatility in module prices, exchange rates, freight, and commodity prices. This may impact on the EPC margin of Prozeal Green Energy as it may not be able to pass on the cost increase to SPVs. The RE sector, including the solar EPC, is highly competitive, with numerous players vying for market share. There is competition from global and regional solar EPC providers. Established competitors along with capable new entrants can pose challenges. The solar EPC industry is also highly fragmented and has been tending towards increased consolidation in recent years. Further, economic downturns and financial instability can reduce available capital and increase costs for renewable energy investments, affecting Prozeal Green Energy's expansion plans.

8.1.2 Challenges

There is counterparty credit risk due to the depleted financial position of most Discoms. Due to legacy issues, higher T&D losses, lack of adequate tariff revisions, lack of timely subsidy support, operational challenges, financial position in most of the State Discoms is weak. However, with competitive tariffs, payment security mechanism, diversification in counter parties largely mitigates the counterparty credit risk. Further, execution risk in under construction projects may impact profitability and in turn liquidity. During monsoon/rainy season, EPC players may not be able to execute projects due to site accessibility, waterlogging etc. which can affect their revenue during these period. However, with in-house EPC expertise and experience in execution of large-scale projects should mitigate this risk. Furthermore, the availability of contiguous land and acquisition challenges associated with land parcels are some of the key challenges that developers are facing. To acquire large tracts of land in a single resourceful location, many stakeholders have to be involved, which slows down the pace of project execution. The 40 GW solar park scheme, which provides land to successful bidders for setting up the projects, is facilitative in this aspect. Availability of timely transmission connectivity is another challenge. To optimize costs, utilization levels, and losses associated with the transmission system, it is crucial to have robust transmission planning. Concerns about connectivity for renewable projects have been raised by the various stakeholders at the appropriate levels. Nodal agencies (PGCIL and SECI) have planned various schemes to reduce grid congestion and enhance connectivity, taking this into account. Green Energy Corridor Scheme and Renewable Energy Zones expected to add ~80 GW of transmission grid capacity taking it to more than 100 GW for RE projects. This will give comfort against the planned capacity additions in renewable energy segment.

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